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See Advertisement, page 51. 1872

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TENDERS.

HIGH CARLEY SANATORIUM, near ULVERSTON.

For Sale, Hydro-Extractor,

26 in. diameter. Can be seen on application to the Medical Superintendent. Offers should be sent to Dr. G. LISSANT COX, Central Tuberculosis Officer, County Offices, Preston. G 745

FLEET (HANTS).

URBAN DISTRICT COUNCIL OF FLEET (HANTS).

NEW SEWERAGE EXTENSION WORKS FOR FLEET, HANTS.

UNEMPLOYMENT RELIEF WORKS.

TO CAST-IRON PIPE FOUNDERS.

The Urban District Council of Fleet (Hants) invite

Tenders for the Supply and

DELIVERY at Fleet, of about 220 Tons, more or less, of CAST-IRON PIPES, varying in size from 3 in. to 24 in. internal diameter, also a number of Bends, Taper Junctions and other Specials.

A copy of the Specification and Form of Tender may be obtained on application, in writing, to Major T. J. MOSS-FLOWER, Civil Engineer, 28, Victoria Street, Westminster, S.W., and Carlton Chambers, Bristol, at his Bristol Office, on and after the 21st December, 1924, on payment of the sum of Three Guineas, which will be returned, provided a *bona fide* Tender be received and is not withdrawn before the acceptance by the Council of one of the Tenders.

Sealed Tenders, endorsed "Tender for Cast-Iron Pipes," are to be delivered at my Office, at Fleet, by Twelve Noon on 1st January, 1925.

The lowest or any Tender will not necessarily be accepted.

Dated this 18th day of December, 1924.

ERNEST NASH,
Clerk to the Council.

Council Offices,
FLEET, Hants. G 751

URBAN DISTRICT COUNCIL OF FLEET (HANTS).

EXTENSION OF EXISTING SEWERAGE AND SEWAGE DISPOSAL WORKS FOR FLEET.

UNEMPLOYMENT RELIEF WORKS.
GENERAL CONTRACT.

The Urban District Council of Fleet invite

Tenders from Responsible and

Experienced Contractors for the CONSTRUCTION of these WORKS, which comprise several miles of Cast Iron and Stoneware Sewers, Brick, Concrete and Cast Iron Manholes, Flushing Tanks, Ventilating Shafts and Columns, Cast Iron Rising Main, Air Mains, and additions to the Sewage Disposal Works, and other incidental work.

A copy of the Specification and Form of Tender, and Bills of Quantities may be obtained and the drawings inspected, on and after a date to be communicated to persons Tendering, on application, in writing, to MAJOR T. J. MOSS-FLOWER, Civil Engineer, 28, Victoria Street, Westminster, S.W., and Carlton Chambers, Bristol, at his Bristol Office, on deposit of a £10 Bank of England Note, which will be refunded provided a *bona fide* Tender be received, and is not withdrawn before the sealing by the Council of one of the Tenders, and provided also that all documents supplied be returned to the Engineer.

The Contractor carrying out the work will be required to comply with the regulations of the Unemployment Grants Committee with regard to the employment of labour during the performance of the Contract, and the work must be actively commenced by 12th January, 1925.

Sealed Tenders, endorsed "Tender for Fleet Sewerage and Sewage Disposal Works, General Contract," are to be delivered at the Council Offices, not later than Noon on the 7th January, 1925.

The lowest or any Tender will not necessarily be accepted.

Dated this 15th day of December, 1924.

(By Order)
ERNEST NASH,
Solicitor & Clerk to the Council.

Council Offices,
FLEET (Hants). G 715

CITY OF LEEDS.

HIGHWAYS AND PERMANENT WAY DEPARTMENT.

The Corporation invite

Tenders for the Supply, etc., of

ONE STATIONARY STONEBREAKING, ELEVATING AND SCREENING PLANT.

Further particulars of the plant to be supplied can be obtained on application to the Highways and Permanent Way Engineer, at 1, Swinegate, Leeds.

Sealed Tenders, endorsed "Tenders for Stationary Stonebreaking Plant," and addressed to the undersigned, must be delivered at this address not later than Ten a.m., on Monday, January 12th, 1925.

J. B. HAMILTON,
Commercial Manager,
1, Swinegate, Leeds.

20th December, 1924. G 742

TAF FECHAN WATER SUPPLY BOARD.

PIPE LAYING—CONTRACT No. 3.

The Taf Fechan Water Supply Board are prepared to receive

Tenders from Competent

Persons for the laying of about 21 miles of steel and cast iron pipes of 37 inch and smaller diameters together with ancillary works in the Counties of Brecknock and Glamorgan, and for the construction of a break pressure tank.

Drawings may be seen, and Instructions to Tenderers and Specifications and Bill of Quantities obtained on and after the 22nd December, 1924, at the Office of Sir ALEX. BINNIE, SON & DEACON, 30, Buckingham Gate, Westminster, S.W., on payment of a cheque for £5 made out to the Taf Fechan Water Supply Board, which amount will be returned on receipt of a *bona fide* Tender.

Sealed Tenders, endorsed "Tender for Pipelaying" should be delivered at my Office at or before Noon, on Thursday, the 15th day of January, 1925.

The Tenders so sent in are to be accompanied by the Bill of Quantities fully priced out, and the Board do not undertake to accept the lowest or any Tender, or to defray any expenses in connection with Tendering, and will only consider such Tenders as are sent in by Contractors who have previously executed works of a similar kind and magnitude.

J. COLENSO JONES,
Clerk to the Board.

Board's Offices,
101, High Street,
Merthyr Tydfil. G 683

CITY OF BIRMINGHAM WATER DEPARTMENT.

BARTLEY RESERVOIR.

The WATER COMMITTEE invite

Tenders for the Construction

of the BARTLEY RESERVOIR, on a site adjoining their existing Reservoir at Frankley, near Birmingham.

The Reservoir will be a Storage Reservoir with a content of over 500 million gallons. The Works will comprise the following:—

An Earthen Embankment with shallow cut-off trench and reinforced concrete core wall, valve tower with reinforced concrete footbridge, outlet culvert and pressure tunnel, inlet culvert and channel, inlet gauge chamber and recorder house, reservoir lining consisting of pre-cast concrete slabs, reinforced concrete in situ-pitching and beaching, road diversions, and other subsidiary works.

Conditions of Contract (which include the Corporation's usual fair wages and conditions of labour clauses). Specifications and Forms of Tender may be obtained on and after December 30th, 1924, from the Secretary, Water Department, Council House, Birmingham.

All applications for Tender Forms must be accompanied by a deposit of £10, which will be returned to the applicant on receipt of a *bona fide* Tender.

The Drawings may be seen at the Water Department Offices (Secretary's Office entrance), Council House, between the hours of Ten a.m. and One p.m., on December 30th, 1924, January 2nd, 6th, 9th, 13th, 16th and 30th, 1925. An Assistant Engineer will be in attendance on these dates between Eleven a.m. and One p.m. After Two p.m. he will attend at the Reservoir site to afford any further information to Tenderers.

Tenderers desiring to have copies of any of the drawings, to assist them in preparing their Tenders, will be supplied with such copies on payment to the Secretary of 2s. 6d. per copy, which amount will not be returned. All Drawings so supplied must be returned to the Secretary under separate cover at the same time as the Tender is submitted.

Tenders must be delivered under seal, addressed to "The Secretary, Water Department, Council House, Birmingham," endorsed "TENDER FOR BARTLEY RESERVOIR, CONTRACT No. 12," not later than Noon, on 26th January, 1925.

The Committee do not bind themselves to accept the lowest or any Tender.

J. H. BROADLEY,
Secretary.

Water Department,
Council House,
Edmund Street,
Birmingham.
19th December, 1924. G 746

APPOINTMENTS OPEN.

THE QUEEN'S UNIVERSITY OF BELFAST.

JUNIOR ASSISTANT IN ENGINEERING.

Applications are Invited for

the POST of JUNIOR ASSISTANT in the Department of Civil Engineering. Salary £300 per annum, duties to commence early in January, 1925.

Further particulars may be obtained from the undersigned by whom applications with testimonials must be received on or before Saturday, January 10th, 1925.

F. H. HUMMEL,
Professor of Engineering. G 750

Estimator Required, Capable

of making estimates from project drawings for mechanical handling plants for coal and other materials. Only men with good experience and proved abilities need apply. State age, experience and salary required.—Address, G 753, Offices of ENGINEERING.

The National Omnibus and

TRANSPORT COMPANY LIMITED, REQUIRE an ASSISTANT WORKS MANAGER, age about 30-35. Manufacturing experience and good knowledge of body work, running repairs and maintenance of rolling stock essential.—Applications, giving full particulars of experience and salary required, to be addressed to the SECRETARY, 206, Brompton Road, S.W.3. Envelopes to be marked "A.W.M." G 695

Engineering. — Small and

Old-established Business, in Leeds, has OPENING for GENERAL MANAGER—small capital may be invested but not essential for first-class man. State age, salary and qualifications.—Address, G 702, Offices of ENGINEERING.

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PETENT ENGINEER to take sole charge of Department in large and old-established Engineering Works handling Sluice Gates, Valves, etc., for Hydro-electric and Irrigation Plants, etc. Wide outside experience and knowledge of design and estimating essential. Only first-class man will be considered and the successful applicant must be prepared to take over duties early in January.—Address, stating age, qualifications and salary required, etc., G 754, Offices of ENGINEERING.

Electric Traction Engineer.

WANTED, by large Manufacturing Firm, ENGINEER with specialised knowledge of design and manufacture of electric railway motors. Must have ability and practical experience in determination of motor requirements for specific electric traction projects. Good remuneration and excellent prospects offered. Only ambitious and progressive men with practical experience need apply. State full particulars, salary required and earliest date commence.—Address, G 756, Offices of ENGINEERING.

CITY OF SHEFFIELD—WATER DEPARTMENT.

APPOINTMENT OF ASSISTANT ENGINEER.

Applications are Invited for

the APPOINTMENT of THIRD ENGINEERING ASSISTANT.

Age about 25 years.

Candidates must be qualified Engineers, have held a similar position, and have had practical experience in connection with the distribution of water, the maintenance of reservoirs and works, distributary pipes, and the methods employed in the detection and prevention of waste.

Commencing Salary £250 per annum. (Grade III.)

Applications, stating age, qualifications and experience, accompanied by copies of three recent testimonials endorsed "Engineering Assistant," to be sent to me not later than Monday, 12th January, 1925.

WILLIAM TERREY,
General Manager.

Town Hall, Sheffield.
17th December, 1924. G 735

BURMA RAILWAYS.

BRIDGE ENGINEER.

The Directors are prepared to receive

Applications from Properly

qualified Candidates for APPOINTMENT as ASSISTANT ENGINEER (Bridge Engineer) for service on the Company's Railway in Burma.

Candidates should be between 25 and 30 years of age, active and of good physique. They must possess a thorough knowledge of girder design and manufacture, and have had a good theoretical training in Engineering knowledge at a recognised Engineering College. Particulars should be given as to whether applicants have had any outside experience of the erection or renewal of bridges either at site or in a bridge builder's yard.

SALARY:—Scale, Rs.550, with annual increments of Rs.50 to Rs.1100 per calendar month. The commencing salary on appointment will be according to age and experience, if 25 years of age Rs.650, if 30, Rs 900.

TERMS:—A three years' agreement in the first instance, first-class free passage to Burma, and home again on satisfactory termination of services.

The selected candidate will be required to pass a strict medical examination by the Company's Consulting Physician before appointment.

Applications (by letter only), giving particulars of applicants' general and technical education and training, and showing in chronological order (with dates) where and how they have been employed from time to time, should be addressed to the undersigned, to be received not later than the 12th January, 1925.

MANAGING DIRECTOR,
199, Gresham House,
Old Broad Street,
London, E.C.2. G 747

Grinders (Surface). — Manu-

facturers of high precision gauges in Woolwich district (S.E. London), REQUIRE First-grade Surface Grinders for production of spline gauges, angle gauge work and other high precision grinding. Only mechanics who are able to work to highest accuracy with slip gauges need apply. Permanency for suitable men, stating experience, age and wages required.—Address, G 589, Offices of ENGINEERING.

Screw Gauge Makers.—

REQUIRED in South-East London district, young SCREW GAUGE MAKERS of highest qualifications. Only men who have had good experience in modern methods of producing hardened screw gauges to N.P.L. limits need apply. State age, wages and experience.—Address, G 590, Offices of ENGINEERING.

Assistant Engineers and

DRAUGHTSMEN. Wanted at once, ONE or TWO ASSISTANT ENGINEERS, experienced in building construction, dock and railway work, as residents on large Factory Construction schemes in England. Also one or two experienced building draughtsmen used to steel construction and heavy engineering work, required in London.

Write, stating age, experience and salary required, to A.R.D., at HORNCASTLES, 60, Cheapside, E.C.2. G 757

Wanted, First-class Designer

to occupy important position in Drawing Office. Must have extended experience in Aerial Ropeways. State particulars of experience, age, salary, etc.—Address, G 755, Offices of ENGINEERING.

Young Assistant for Design

Office of firm manufacturing centrifugal pumps, one familiar with single stage pumps in particular required. Good prospects for suitable man. State age, experience and salary required. —Address, G 748, Offices of ENGINEERING.

Draughtsman Required for

Machine Tools. Must be accurate and thoroughly reliable. Reply, stating qualifications.—Address, ALPHA, WM. PORTEOUS & CO., Advertising Agents, Glasgow. G 641

Required First-class Draughts-

MAN with experience in Centrifugal and Hydro-extractor design.—Address, G 685, Offices of ENGINEERING.

Experienced Draughtsman

REQUIRED with knowledge of Cement and Crushing Machinery. Apply, giving full particulars of age, experience and salary required to W.J.C., EDGAR ALLEN & CO., LTD., Imperial Steel Works, Sheffield. G 688

Wanted, Draughtsman with

good experience of hydraulic work, particularly of cranes and hoists. Applications must state experience, salary required and age, which should be between 30 and 40 years.—Address, G 743, Offices of ENGINEERING.

Designing Draughtsman

REQUIRED in connection with coal and mechanical handling plants. Only men with complete knowledge and first-class experience need apply. State age, experience and salary required.—Address, G 752, Offices of ENGINEERING.

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Resident Engineer or Con-

tractor's Agent, Position Wanted as. Roads, Bridges, Docks, Railways.—Address, G 569, Offices of ENGINEERING.

Engineer, Practical, Tech-

nical, Commercial. Good Organiser, 47, thirty years' experience Home and Abroad. Open to accept position as Export Manager Home, alternatively, Manager or Representative abroad.—Address, G 708, Offices of ENGINEERING.

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Sugar Consultant; experienced

as Chemist and Manager.—CHARLES FERGUSON, F.C.S., 19, Craven Street, W.C.2. Phone: Gerrard 8606. G 638

WANTED, &c.

Woodworking Machinery.—

Good AGENT WANTED by Belgian Manufacturer for London and England.—Apply to "*Le Progres Minier et Metallurgique.*"—51, rue de Namur, 51, Brussels, Belgium. G 703

The Proprietors of Patent

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TESTS OF HYDRAULIC TURBINES OF THE LAWACZECK TYPE.

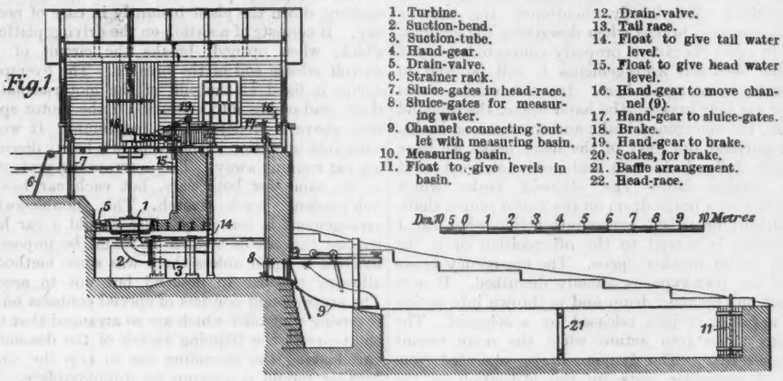
By PROFESSOR A. H. GIBSON, D.Sc., M.Inst.C.E.

IN September of the present year the writer had the opportunity of carrying out a series of tests on a number of hydraulic turbine runners in the testing station of Messrs. Aktiebolaget Finshyttan, Finnshyttan, Sweden.

This testing station was established in 1904, and has since been in constant use. During recent years very extensive series of tests have been carried out, tending more especially to the development of low-head runners of high specific speed. The firm has recently undertaken the development of runners of the Lawaczeck type, and is now engaged in the manufacture of two turbines using such runners for the Swedish Government's hydro-electric station at Lilla Edet. These turbines are, in point of size, the largest yet constructed in any country, the runner diameter being 6 m. (19 ft. 8 in.), and they will develop 10,000 h.p. under the mean available head of 6·5 m.

The testing plant can be used for experiments on turbines either of the horizontal or vertical-shaft types. The general arrangement with vertical-shaft turbines is shown in Fig. 1. Water is supplied from a canal to an open forebay in which the turbine is mounted. The vertical shaft carries a water-cooled brake drum at its upper end. A Prony brake is used, the weight of the brake band, blocks, and arm being supported by long thin wire cables suspended from the ceiling. The tail water is discharged through a sluice gate, and this discharge is caught in a scoop, by which it may be diverted for a measured time into a large calibrated measuring tank, so that all measurements of volume are on a volumetric basis. The sluice gate has been carefully calibrated for different heads and openings by means of the measuring tank, so that individual tests may be carried out very quickly and yet with a high degree of accuracy. The surface levels of the forebay and of the tail water are measured directly by means of floats. The maximum available head is approximately 3 m.

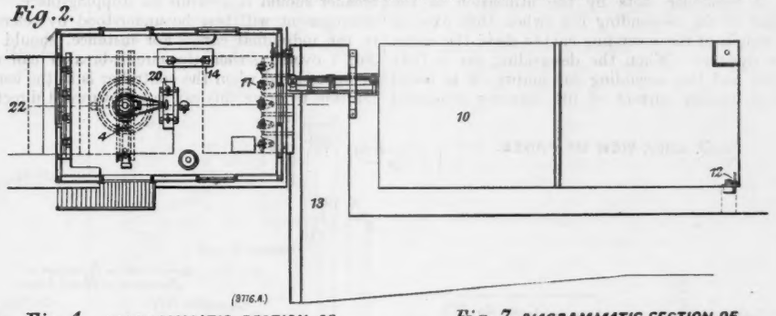
Fig. 1.



1. Turbine.
2. Suction-bend.
3. Suction-tube.
4. Hand-gear.
5. Drain-valve.
6. Strainer rack.
7. Sluice-gates in head-race.
8. Sluice-gates for measuring water.
9. Channel connecting outlet with measuring basin.
10. Measuring basin.
11. Float to give levels in basin.
12. Drain-valve.
13. Tail race.
14. Float to give tail water level.
15. Float to give head water level.
16. Hand-gear to move channel (9).
17. Hand-gear to sluice-gates.
18. Brake.
19. Hand-gear to brake.
20. Scales, for brake.
21. Baffle arrangement.
22. Head-race.

Datum 0 5 0 1 2 3 4 5 6 7 8 9 10 Metres

Fig. 2.



(8776.A)

Fig. 4. DIAGRAMMATIC SECTION OF FRANCIS TURBINE.

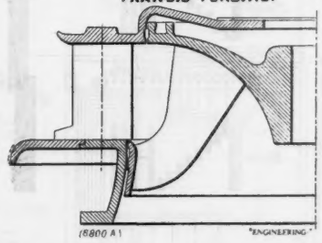


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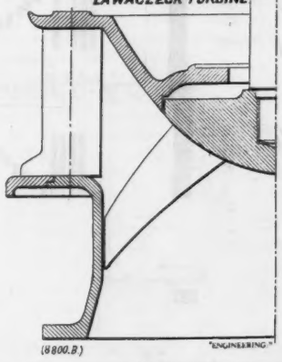
Fig. 7. DIAGRAMMATIC SECTION OF LAWACZECK TURBINE



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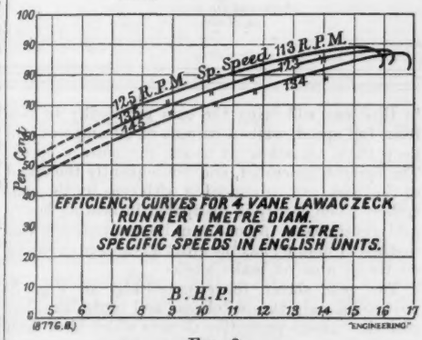


FIG. 8.

Four runners were tested by the writer. One of these was of conventional Francis type (Figs. 3 and 4), having a maximum diameter of 500 mm. and a specific speed of about 255 in metric units under conditions of maximum efficiency, and of 274 at maximum load. The corresponding figures in English units are 57·5 and 62.

The other three were Lawaczeck runners, 460 mm. in diameter, designed respectively for low, medium, and high speeds. These runners, while giving good results at moderate specific speeds, are specially well adapted for use in high-speed, low-head units. They have relatively few vanes—ranging from four upwards. Two of the runners tested are shown in Figs. 5 and 6, and, diagrammatically, in Fig. 7.

FIG. 3.

FIG. 5.

FIG. 6.

The details of these various runners are as follows :—

Runner.	Number of		Designed Specific Speed.	
	Vanes.	Guide Vanes.	Metric Units.	Foot Units.
Francis	14	16	255	57·5
Lawaczeck I ..	11	32	235	53
Lawaczeck II ..	9	32	400	90
Lawaczeck III ..	4	32	600	135

Each runner was mounted as a vertical-shaft unit in an open setting and was tested over a wide range of speeds and gate openings under a head of approximately 8 ft. The main results of the tests are given in the next page.

It will be noted that the maximum efficiencies

are in every case very high, especially for runners of such small diameter. The comparison between the performance of the Francis runner and that of the Lawaczeck runner of approximately the same specific speed is of interest as showing that the latter type, although essentially a high-speed runner, is

Turbine.	Specific Speed. R.P.M.	Efficiency at ¼ Load.	½ Load.	Full Load.	Maximum Efficiency.
Francis ..	57·5	82·6	89·0	78·6	89·3
Lawaczeck I ..	58	80·0	85·7	76·0	89·0
Lawaczeck II ..	87·5	75·0	85·6	81·0	87·0
Lawaczeck III ..	113	70·6	83·2	85·0	89·0
	123	67·5	80·5	86·0	88·0
	134	64·5	77·5	84·5	87·2
	157	—	—	83·3	84·8

little inferior to the conventional type over the range from one-half to full gate at moderate speeds. The good performance of the four-vaned high-speed runner over a considerable range of speeds and loads, as indicated in Fig. 8, is worthy of note. It is of interest to mention that this runner is very similar to the 6 m.-diameter runner now being constructed for Lilla Edet.

THE PENANG HILLS RAILWAY.

(Concluded from page 792.)

Before concluding our description of this very interesting work, we propose to refer in rather more detail than we have yet done to the electrical arrangements which have been installed in connection with the operation of the haulage engines, and also to the signalling system of the railway. Each haulage engine is provided with gear of which a diagram is given in Fig. 79, above. This gear controls the 75 h.p. 500 volt D.C. interpole motor which operates the engine and also the various electrical braking arrangements. A switchboard, indicated at the upper left-hand corner of Fig. 79, contains a double-pole isolating switch and a double-pole circuit breaker. This breaker has an auxiliary tripping arrangement to which we shall refer later. The circuit beyond the breaker bifurcates, one limb connecting to the motor controllers and the other to the brake solenoids. These arrangements are indicated in the figure, from which it will be seen that there are two controllers, one of which controls the direction of running of the motor and the other the speed. This second controller can be used for braking by reversing its direction of motion, and it is this brake which is used for controlling the engine when the load travelling down the hill is heavier than the load coming up.

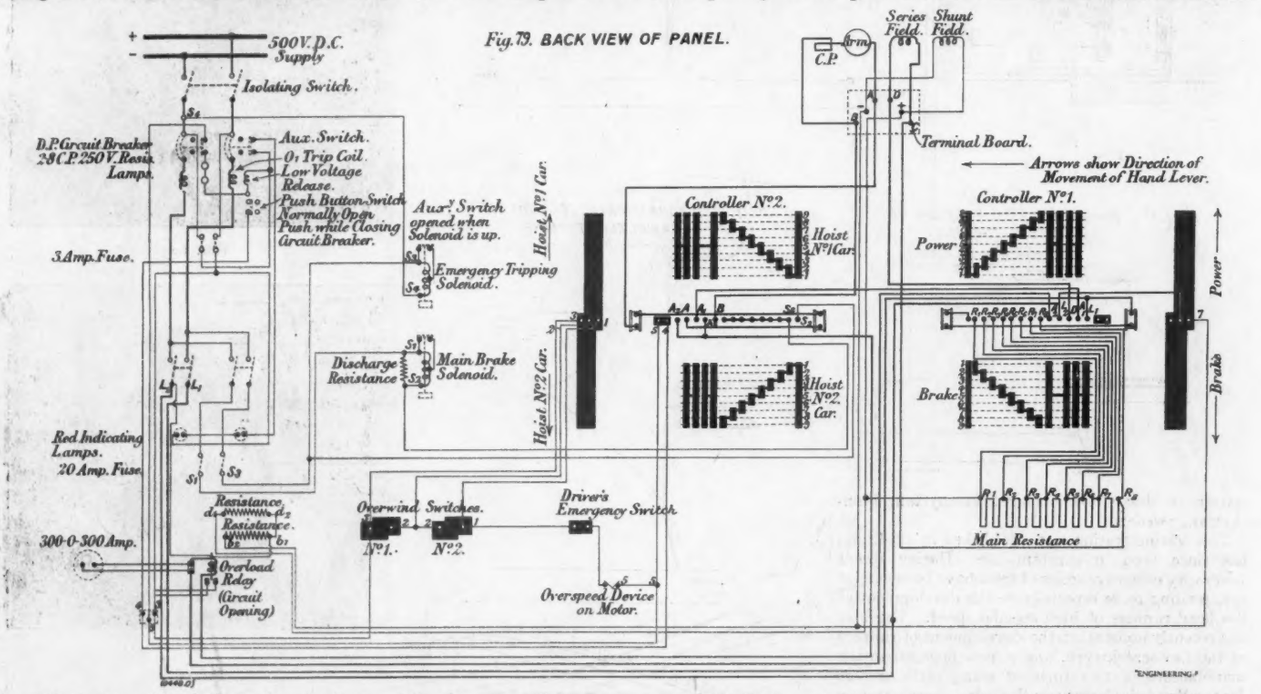
The most interesting features of the gear, which is shown in Fig. 79, are concerned with the braking arrangements. It will be realised, of course, that the various brakes fitted in connection with the haulage-engine, and indicated in this figure, are quite independent of the brakes on the cars themselves. We briefly mentioned the various haulage-engine brakes when describing the engines, but in order to give a properly connected account of the electrical arrangements it will be well to refer to them again here. In each engine room there are four brakes—the hand brake, the solenoid brake, the emergency brake and the dynamo brake. The purpose and duty of the hand brake we have already fully dealt with and need not treat of it any further here. The solenoid brake which operates on a brake drum on the motor pinion shaft, as already described, comes into action when No. 1 controller is moved to the off position or if the main circuit breaker opens. The emergency brake is of the post type, as already described. It acts direct on the main drum and is thrown into action by a falling weight released by a solenoid. The brake comes into action when the main circuit breaker trips. The dynamo brake, operated from No. 2 controller, acts by the utilisation of the weight of the descending car (when that exceeds the weight of the ascending car) to drive the motor as a dynamo. When the descending car is fully loaded and the ascending car empty, it is found that a braking current of 100 amperes generated in this way will bring the cars practically to rest from full speed, while a current of 50 amperes will keep them travelling at about the correct speed. The current generated, and consequently the speed of the cars, can be regulated with ease by the controller. The energy is dissipated in heating heavy grid resistances. Apart from its convenience this method of braking has the great advantage of saving continual wear on brake blocks.

The gear shown diagrammatically in Fig. 79 covers not only the switchgear and controllers, but also the various protective devices which have been installed in connection with the winding engines. All these devices operate in connection with the main circuit-breaker, and either cause it to open or prevent it from being closed. The effect of the opening of the breaker is to apply the emergency and solenoid brakes as previously described. The safety devices have been worked out in great detail, and there are seven methods of opening the breaker, of which five are arranged in series in such a way that if one of them is not in proper commission the breaker cannot be closed to start the engine. The different methods of protection may be classed as: (1) emergency; (2) overspeed; (3) Car No. 1 overrunning its stopping-place; (4) Car No. 2 overrunning its stopping-place; (5) braking overload; (6) low-voltage release; (7) motor overload.

The emergency protection allows of the driver shutting down the plant instantly in case of necessity. It consists of a switch on the driving platform which, when opened, breaks the circuit of the no-volt release coil of the breaker. The overspeed device is fixed at the end of the motor-armature shaft, and comes into operation if the motor speed rises above a predetermined maximum. It would come into operation in the event of a heavy descending car running away. The overrunning protection is the same for both cars, but each car has an independent track switch. This double-switch arrangement is necessary, since should a car have tripped the circuit-breaker it would be impossible to close it again unless there was some method of allowing the car to descend but not to ascend. The arrangement consists of special contacts on the reversing controller which are so arranged that they short-circuit the tripping switch of the descending car, leaving the ascending car to trip the circuit breaker should it overrun its stopping-place. The arrangement will best be understood by reference to the individual cars. For instance, should Car No. 1 overrun, then the circuit-breaker can only be kept closed when the controller is in the correct position to drive this car in a downward direction. Should the controller be moved to such a position that it would drive the car still further past its correct stopping-place, then the breaker would at once open. The arrangement ensures that, should a car overrun from any reason, then no power can be applied to it except to cause it to move in the opposite direction—that is, downwards.

The protection, which we have called "braking overload," is to some extent a protection against misjudgment on the part of the driver. It would only come into operation should the speed become too high and the driver suddenly apply the dynamo-brake too rapidly. This would cause a very heavy current to flow and cause the overload coils to trip the breaker, resulting in the application of the brakes and the bringing of the cars to a standstill. The low-voltage release is an obvious and well-known form of protection which comes into operation in case of the power-supply failing. The motor-overload protection is also common in many applications, and would come into operation

Fig. 79. BACK VIEW OF PANEL.



should a fault occur on the motor. It has a further definite duty in this case, however, and protects the motor, rope, and winding engine should the driver on a car apply his hand brake during the normal running of the railway. Other protective features of the gear consist in the interlocking of the two controllers so that it is impossible to reverse Controller No. 1 until the power controller No. 2, has been brought to the off position. A final possible source of trouble lies in the driver leaving his controllers in some running position and closing the circuit-breaker after it has opened for some reason. This he cannot do until he has brought his reversing controller to its off position. If the controller is not in that position, the breaker will not stay closed. As we have already mentioned, the whole of this control gear was supplied by the British Thomson-Houston Company, except the brake solenoids which were supplied by Mr. George Ellison.

The railway is operated from the Penang electric supply. An 11,000 volt 3-phase line has been carried

Fig. 80.

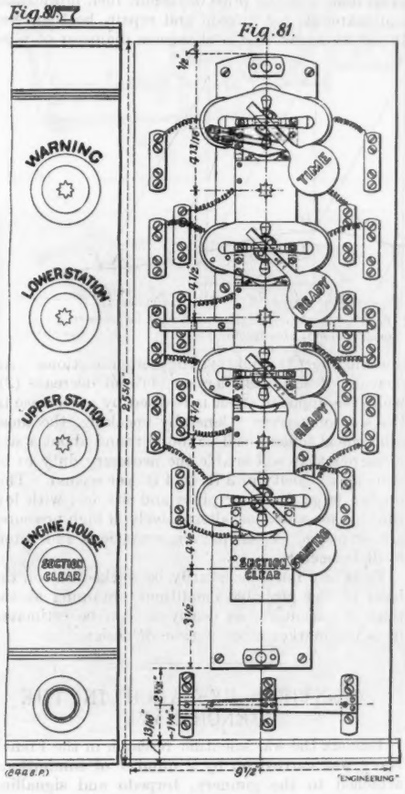


Fig. 81.

to a substation on the top of the Hill, where the current is converted to the necessary D.C. supply for the railway. Step-down transformers give an A.C. supply for distribution on the Hill. The cables supplying the Hill run up the railway itself and can be seen in some of the illustrations which accompanied the earlier part of this description. On the lower section there are two A.C. cables run inside the track hanging on the sleepers. On the upper section there are three cables, since the D.C. cable feeding the middle winding engine has also to be accommodated on this section. These are run on brackets at the side of the track supported from the holding-down bolts of the sleepers. The earthed return wire from the middle station is run along the rail and held in place by clips attached to the sleepers. The cars are lighted by 100-ampere-hour batteries, complete spares being provided so that one set may be charged while the others are in commission.

Our final illustrations, Figs. 80 and 81 on this page show the signalling arrangements. The gear, which is of quite special type, was supplied by Messrs. Tyer and Co. It will be realised that both cars on a section of this railway are started simultaneously by the driver of the haulage engine who cannot see the operations of the car men. In the arrangement adopted the driver exchanges both bell and visual signals with the stations, but the gears are so interlocked that the driver cannot despatch the "starting" signal until he has received the "ready" signal from both stations. Signalling boards of the type illustrated in Figs 80 and 81 are fixed in the engine room and on both station platforms. As will be seen, each board consists of a plate with four holes with magnetically controlled shutters behind them. The coils which operate the shutters are fixed at the back of the signal board, and current passes through each coil in turn first in one direction by the operation of the various instrument switches, and then in the opposite direction by the operation of a master switch which has the effect of returning all switches to clear.

The method of operation is as follows: Just before the correct starting time, the haulage-engine driver depresses his switch which gives the warning signal "time" and rings a bell in both stations. He continues to give this signal at intervals until the station master at the lower station answers by depressing his switch which rings a bell at the upper station and in the engine room and gives the signal "lower station ready" on all three instruments. The station master at the upper station then gives the same signal to the two other positions. The driver then having received his "ready" signal from both stations gives his starting signal which again rings a bell at both stations and gives the "starting" signal on all three instruments. He then starts his engine. The signals are returned to clear by the cars, the connection being made by track switches which are arranged so that the signals can only be returned to clear by the ascending car.

The track switches are spaced at intervals along the track, and, apart from their duty in returning the signals to clear, they operate a warning bell fixed above the control platform in the engine-room. The first warning bell is given by the fourth track switch, which is situated about 30 ft. below the station. This gives the driver warning to stand-by. The second warning signal is given by track switch No. 3, which is placed in such a position that the driver should apply the brakes at full power when the signal is given. Should he fail to do so the car will strike the overwind safety device and automatically apply the emergency brake as before explained.

In addition to this signalling system, the railway is equipped with two telephone systems. The first, the service telephones, connects the various stations to the two engine rooms. The other, the track telephone system, is quite independent from the service telephones. The track telephone wires are carried on poles adjacent to the track and are installed to permit of speaking from a car to the engine-house in the event of trouble either to a car or the track. The method of using them is very simple. If a car conductor has trouble and wishes to stop the car he does so by joining the two wires together by means of a brass fork at the end of a pole. This rings a bell on the engine-room telephone. The engine driver then stops the haulage, and the conductor by hooking his fork on to the wires so that the two arms of the fork cross the two wires and make connection with the engine room.

In concluding our account of this very interesting railway, we should say that a paper dealing with it was read by the engineer, Mr. A. R. Johnson, before the Engineering Association of Malaya, in September, 1921, and a further paper dealing with the electrical equipment was read by Mr. Thomas Rogers, A.M.I.E.E., before the same association on December 16, 1923. We are indebted to both of these papers for assistance in the preparation of this description. We should also mention that Messrs. Preece, Cardew and Rider acted as consulting engineers in connection with the electrical equipment of the railway.

THE DESIGN OF OIL FUEL PIPE LINES.

By W. G. WATKINS.

(*Concluded from page* 825.)

To illustrate the use of the foregoing, the following examples are given:—

(1) Required, the size of main capable of delivering 400 tons of Mexican oil per hour, at a distance of four miles from pumps, with an average temperature of 100 deg. F. Pressure at pumps not to exceed 200 lb. per square inch, and velocity not to exceed 6 ft. per second.

Fig. 1 gives S.G. of Mexican oil at 100 deg. F. = 0·929.

Fig. 2 gives weight per cubic ft. S.G. 0·929 = 58 lb. say.

From the latter, $\frac{2240}{58} = 38{\cdot}62$ cub. ft. per ton, which multiplied by 400 = 15,448 cub. ft. required to be passed per hour. Dividing by 3,600 we obtain a figure for Q = 4·3 cub. ft. per second. The limiting velocity, v, being 6 ft. per second $\frac{Q}{v} = \frac{4{\cdot}3}{6{\cdot}0} =$ 0·72 sq. ft. area of pipe. 12 in. diameter pipe meets this condition.

The viscosity μ of Mexican oil at 100 deg. F. = 0·371 (Fig. 5) hence the flow at 6 ft. per second must necessarily be streamline, and from $Pm = \mu \times 36{\cdot}5 \times 6 = 81{\cdot}249$ lb. per sq. in. per mile, which multiplied by distance = 4 × 81·249 = 324·996 lb. per sq. in., which does not comply with the specified limiting pressure at pumps. (We obtain the same result approximately by inspection of Fig. 10, where for a value of $\mu = 0{\cdot}371$ the pressure drop in 12 in. diameter pipe per mile is 13·6 when $v = 1$ ft. sec., and hence 13·6 × 6 × 4 = 326·4 lb. per square inch.)

By further inspection of the same figure we see that in a 14 in. pipe the pressure drop is 10 lb. per square inch per mile run when $v = 1$ ft. sec. and as the area of a 14 in. pipe is 1·07 sq. ft. the required velocity $\frac{Q}{A} = \frac{4{\cdot}3}{1{\cdot}07} = 4{\cdot}018$ ft. per second, and therefore the pressure drop for the distance quoted = 10 × 4·018 × 4 = 160·72 lb. per square inch. Checking this result by our approximate table we have μ 27 × 4·018 × 4 = 161·5 lb. per square inch, which is within reasonable limits of accuracy, any error being on the side of safety.

Checking again by reference to Figs. 11 and 12, we find that for Mexican oil at 100 deg. the pressure drop in 14 in. pipe is shown as about 10 lb. per square inch per mile, giving a total pressure drop of 160·72 lb. per sq. in. We may therefore safely take 14 in. as the requisite size, seeing that the average temperature in the length under consideration was given in the problem.

If, however, the initial temperature at the pumps is the only factor known, then we require to know, at least approximately, the temperature-distance history of the oil or oils in question. Data on the subject are very scarce, but from observations made by the writer, the fall of temperature of Mexican oil in a 14 in. pipe line appears to vary from 3 deg. to 5 deg. F. per mile run, when flowing at a velocity of between 3 ft. and 4 ft. per second. If, therefore, we take the higher figure as the worst case likely to occur in our pipe line, we obtain the following approximate temperature—distance—history:—At pumps, say, 100 deg. F., at 1 mile, 95 deg.; at 2 miles, 90 deg.; at 3 miles, 85 deg., and at the 4th mile, 80 deg. F. From these figures the average for the 1st mile is 97·5 deg. with $\mu = 0{\cdot}41$; for the 2nd, 92·5 deg. with $\mu = 0{\cdot}52$; for the 3rd, 87·5 deg. with $\mu = 0{\cdot}68$ and for the 4th, 82·5 deg. with $\mu = 0{\cdot}96$, thus very materially increasing the pressure gradient, and the corresponding pressure drop, at a velocity of 4·018 ft. per second becomes 45·2 lb., 57·25, 73, and 94·4 lb. per square inch for the 1st, 2nd, 3rd and 4th miles respectively, or a total of, say, 270 lb. per square inch for the 4 mile run. Mexican oil is of course, peculiarly susceptible to temperature changes, and is by far the most difficult to cater for, unless the temperature can be kept at 100 deg. F. or over. It would seem that for this and similar oils either the pumping stations must be comparatively close together, or intermediate heaters must be introduced every few miles. If this is impracticable, then the initial temperature at pumps must be in the vicinity of 140 deg. or 150 deg. F.

Other oils do not appear to show such great variations in temperature, and, further, are not affected to nearly the same extent so far as viscosity is concerned. Reference to Figs. 3, 4 and 5 will make it clear that in the case of Scotch shale oil a change of 10 deg. F. does not increase the viscosity by more than 0·003 in the worst case; Borneo by

0·005; Kimmeridge shale by 0·07; Texas by 0·064; Trinidad by 0·63, while Mexican between 60 deg. F. and 50 deg. F. increases in viscosity no less than 4·50. It should be noted, too, that Persian oil shows very rapid increases in viscosity as the temperature falls below 70 deg. F. and between 50 deg. F. and 40 deg. F. rises from 0·26 to 2·08, an increase of 1·82.

From the foregoing, and particularly by inspection of the figures above referred to, the importance of careful regulation of the temperature will be more clearly realised. It is hoped that further observations will enable definite values to be assigned for the temperature drop in pipe lines, for most of the fuel oils in common use, and, in the meantime the writer will welcome any information, based on actual observations, that may be available.

The following formula has sometimes been used to connect temperature change to distance :—

$$\frac{\text{Log}\left(\frac{t_0 - T}{t - T}\right)}{\text{Log}\left(\frac{t_0 - T}{t_1 - T}\right)} = \frac{y}{y_1} \quad . \quad . \quad . \quad . \quad . \quad \text{C.}$$

where T = Temperature of air, earth, mud or water surrounding the pipe.
t_0 = Original temperature of oil.
t = Temperature of oil at distance y.
t_1 = " " " y_1.
y_1 = A known length of line for which t_1 is known.
y = Any distance along line.

From this if we know the length of run y_1 and the final temperature t, at this point; the original temperature t_0 and the temperature T, the rate of temperature change with distance may be calculated, and the hydraulic gradient line or curve determined therefrom, but the formula must be used with caution as the phenomena presented by head losses in pipe lines are not well established or understood. Further and exhaustive investigations into the heat losses in oil pipe lines are imperative to enable the changes in vicosity to be accurately forecasted and thus permit of the utmost economy in design.

The use of a gradient line as described above is probably best explained by an example, and the data assumed are as follow :—

1. Diameter of line, say, 12 in.
2. Length of line, say, 100 miles.
3. Required capacity of line, 360 tons per hour.
4. Effective pressure at pumps, 750 lb. per square inch.
5. Oils to be handled, Persian, Borneo, Texas.
6. Working temperature, average, 60 deg. F.

In such a case we must base our calculations on the oil having the highest viscosity at the specified working temperature. Inspection of Fig. 3 shows that Borneo oil at 60 deg. has a viscosity value of 0·0086, while Fig. 4 indicates a value of 0·114 for Persian and 0·1185 for Texas. We therefore take Texas as the basis for our investigations.

From Fig. 1 we see that the density of Texas oil at 60 deg. is about 0·916 S.G. and Fig. 2 shows that the weight per cubic foot is 57·2 lb. $= \sigma$. The required capacity being 360 tons per hour, the rate of discharge per second must be equal to

$$\frac{360}{60 \times 60} = \frac{360}{3600} = 0{\cdot}10 \text{ tons or } 224 \text{ lbs. and } \frac{224}{\sigma} = Q,$$

which gives us $\frac{224}{57{\cdot}2} = 3{\cdot}9$ cub. ft. per second $= Q$.

The area of a 12-in. pipe being 0·7854 sq. ft., then $\frac{Q}{A} = V = \frac{3{\cdot}9}{0{\cdot}7854} = 4{\cdot}96$ ft. per second or, say, 5 ft. per second, is the required velocity.

From the foregoing the value of $\frac{D\,v\,\sigma}{\mu} = \frac{1 \times 5 \times 57{\cdot}2}{0{\cdot}1185} = 2412$ indicating a case on the border line between streamline and turbulent. As we are dealing with comparatively mobile oils, to be on the safe side, it will be better to treat this as a case of turbulent flow, and from Fig. 9 we see that for a value of $\frac{D v \sigma}{\mu}$ between 2,400 and 2,500 the value of $f = 0{\cdot}044$. Then by formula A :—

$$P_m = \frac{440 f \sigma}{d} \cdot \frac{v^2}{2g} = \frac{440 \times 0{\cdot}044 \times 57{\cdot}2 \times 5 \times 5}{12 \times 2 \times 32{\cdot}2} = 35{\cdot}82 \text{ lbs.}$$

or say 36 lbs. per sq. in. per mile.

Checking by the formula given in the National Physical Laboratory's Report on Fuel Oils, 1914, of $h = 4f\frac{L}{d} \cdot \frac{v^2}{2g}$ where f is a coefficient of friction having only one-fourth the value given in Fig. 9 and L and d are in feet, h being head of oil in feet, we get $\frac{4 \times 0{\cdot}011 \times 5280 \times 5 \times 5}{1 \times 2 \times 32{\cdot}2} = 90{\cdot}2$ ft. which multiplied by 0·397 lb. (the weight of a column of 12 cub. in. of oil) $= 0{\cdot}397 \times 90{\cdot}2 = 35{\cdot}82$ lb. per square inch per mile, which is in agreement with our previously obtained result.

It should be noted that had we decided to treat the case as one of streamline flow, the result would have been considerably lower, since Fig. 10 shows that for a value of $\mu = 0{\cdot}1185$ the Pm at 1 ft. per second in a 12-in. pipe is about 4·3 lb. per square inch, or the total at a velocity of 5 ft. per second — 21·5 lb. per square inch per mile. The nature of flow when so close to the $\frac{Dv\sigma}{\mu}$ limiting value of 2,500 is, however, so extremely likely to fluctuate between streamline and turbulent that it is wise to take the case giving the higher pressure drop. A further reason for the procedure adopted in this case is that with the less viscous oils the flow at 5 ft. per second is undoubtedly turbulent.

Fig. 14.

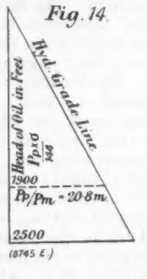
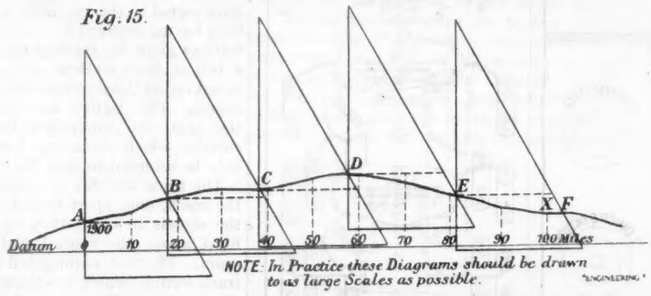


Fig. 15.



NOTE. In Practice these Diagrams should be drawn to as large Scales as possible.

"ENGINEERING"

The effective power of our pumps being 750 lb. per square inch, obviously the extreme range of these will be given by the relation

$$\frac{\text{Pressure at Pumps}}{\text{Pressure drop per mile}} = \frac{Pp}{Pm} = \frac{750}{36} =$$

20·8 miles = horizontal range of pumps.

If we now convert the pumping pressure into equivalent head of oil we can construct the hydraulic grade line. We therefore divide Pp by the weight of a column of oil 1 in. square by 12 in. in height $= \frac{750}{0{\cdot}397} = 1{,}900$ ft. approximately, and plotting as a right-angled triangle to any convenient scales, on a base equal to 20·8 miles, we obtain a diagram such as Fig. 14.

In this case we have assumed that the temperature will remain constant throughout the run, which is within the bounds of probability for the conditions stated. From this it follows that the density and viscosity also remain constant, so that the grade line is straight.

If the pipe line is laid on undulating ground, as usually happens, it is advisable to extend the base line of the grade diagram to some convenient distance in excess of that actually corresponding to the pumping pressure, as indicated in the figure. The reason for this procedure will appear later.

We then set up a profile diagram along the route of pipe line giving heights above datum. This is to the same scales as the grade line has already been drawn, and it is to be observed that this is not a section of heights plotted against horizontal distance, but of heights relative to distances on pipe line.

We will assume that the section is as in Fig. 15, A being the first station and X the last. If we now cut out in stiff card, to form a template, the grade line previously calculated, we have a ready means of arriving at the requisite positions for other pumping stations. The base line of the template is kept horizontal throughout the operations, and the template is adjusted until the 1,900 ft. mark coincides with the zero point at A, as indicated by dotted lines. The point B where the hypotenuse of the triangle cuts the profile gives the position of the second pump station. The process is repeated by placing the 1,900 ft. point at B, and finding C and so on. It will be obvious that the steeper the slope of the ground the closer together will the pumping stations be placed, when pumping up hill, the reverse being the case when the crest is passed and the pipe line is falling in the same direction as the flow. It may be found that the end of the line does not coincide with the final position found. In this case a slight revision of values may be necessary, but it is easily got over either by adjusting the positions of the pumps, varying the temperature of the oil, increasing or decreasing the pumping pressure, or in some other way dictated by circumstances.

With the completion of the diagram, the problem may be considered to be solved, so far as the actual diameter of the line and location of pumping stations is concerned. Before finally deciding on our scheme, however, the question of annual costs should be gone carefully into. These costs will naturally fall under two headings : (1) Fixed charges, which will be proportional to first cost, and comprise interest on capital expended, sinking fund repayments and the like; and (2) operating costs, depending on the duty to be done and the price of labour, fuel, lubricants, and materials for upkeep and repair, heating, &c. It will be found that a change in diameter of pipe line will affect (1) and (2) in opposite directions. An increase of size will increase (1) and decrease (2), while the opposite effect is realised by a decrease in the size of carrier. Generally speaking, the most economical scheme will be found round about a size of carrier that will enable the necessary duty to be done at a velocity of 3 ft. to 4 ft. per second. This implies large diameter pipes and fittings, with low working pressures, or, alternatively, if high pressures are employed, fewer pumping stations and intermediate heaters.

Each case must necessarily be worked out on the basis of the probable conditions obtaining at the time of execution, as nearly as can be estimated from the market rates at time of design.

SCIENTIFIC RESEARCH IN THE FRENCH NAVY.

Before the war scientific research in the French Navy was carried on by a number of committees, attached to the gunnery, torpedo and signalling schools; but by an administrative order for which it is difficult to find a reason, they were suppressed on mobilisation in 1914. Submarine warfare gave them a new existence, though in an altered form. Between 1916 and the armistice several ministerial decrees constituted new committees, but it was not until July, 1921, that all bodies and committees concerned with scientific research in the French Navy were given a definite organisation. The centre of the system is the *Centre d'Etudes de Toulon*, which is an amalgamation of the research committees on coastal artillery, optics and telemetry, mines and depth charges, and submarine detecting mechanisms, and a co-ordinating body for those other committees which cannot be centralised under it.

The latter are the committees on wireless telegraphy, submarines, fleet gunnery, and fleet torpedo work. The two last must, of necessity, be accommodated in sea-going ships, and the cruisers Pothuau and Thionville have, in consequence, been allocated to them. The head of the *Centre d'Etudes* is a post captain, who has under him a number of civilian scientists and naval officers. The work of co-ordinating the investigations of those committees which are not immediately attached to the *Centre d'Etudes* is carried out by

SIX-TON STEAM WAGON.

CONSTRUCTED BY MESSRS. JOHN FOWLER AND CO. (LEEDS), LIMITED, ENGINEERS, LEEDS.

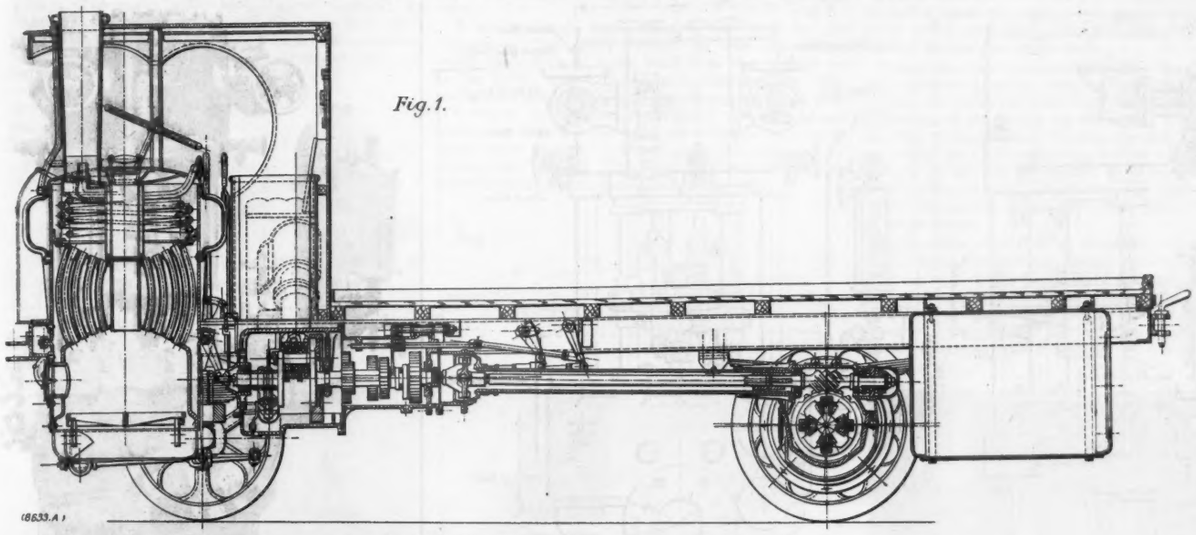


Fig. 1.

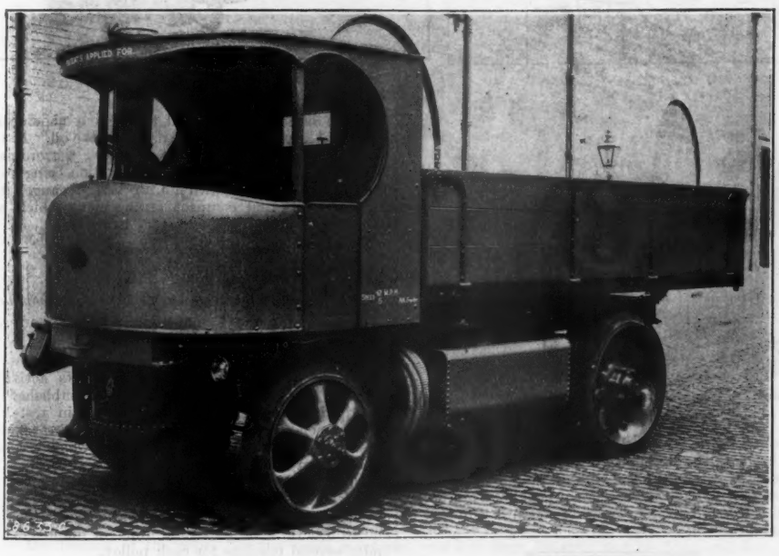
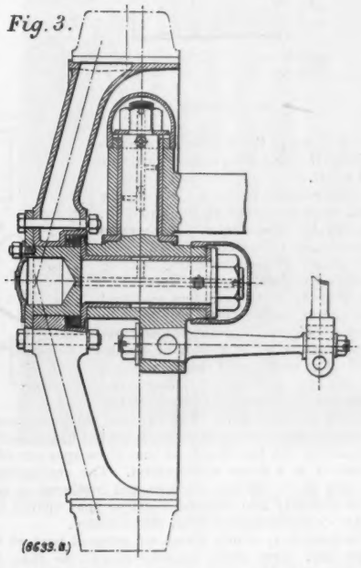


FIG. 2.

Fig. 3.



allowing the captain in charge to correspond direct with the commanders-in-chief afloat, with the admiral in charge of the training squadron, and with all bodies and naval units which are either carrying out work of a scientific or quasi-scientific kind.

The *Centre d'Etudes* has paid great attention to collecting information upon the work which is being, or has already been, carried out on scientific problems. The problem of making a running bibliography of scientific investigation has been given much consideration, but it will probably be quite impossible ever to collect all the results of contemporary research. Practically the whole field is, of course, covered by a number of scientific journals. The *Centre d'Etudes* has got together all the periodicals which publish the results of modern research, and has catalogued the lists into a subject card index. A naval commander is in charge of this "service de documentation," and it is his duty to ensure that all officers or committees doing research work are at once notified if work is being done elsewhere on their subjects. The library and card index of the *Centre d'Etudes* are public; even foreign officers may visit it if they wish. The laboratory seems to be singularly well equipped, and contains about a dozen special *salles de recherches*. At the beginning of this year it was investigating over 60 scientific problems which had been referred to it by the officers of the fleet or the other committees.

THE FOWLER STEAM WAGON.

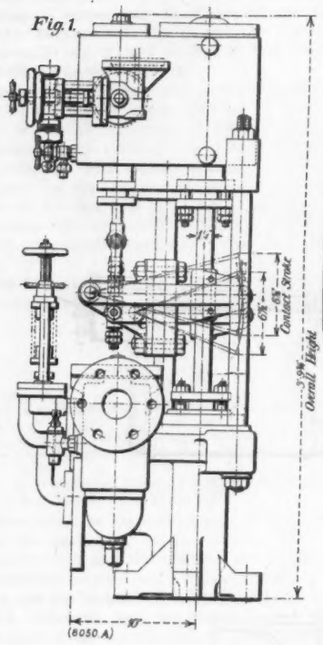
As manufacturers of traction engines for about three-quarters of a century, Messrs. John Fowler and Co. (Leeds), Limited, of Leeds, have an unsurpassed knowledge of the requirements of steam-driven road-vehicles, and their experience in this connection has been turned to account in the steam-wagon which they are now manufacturing. The wagon in question, which is illustrated in Figs. 1 to 3, above, is designed to carry a load of 6 to 7 tons easily up a gradient of 1 in 6, and if fitted with a trailer will haul 10 to 12 tons up a gradient of 1 in 10 on good average roads. The standard body is 14 ft. 6 in. long by 6 ft. 9 in. wide, with a wheelbase of 11 ft. and a wheel track of 6 ft. 9 in. The overall length of the vehicle is 20 ft., the maximum height is 8 ft. 8 in., and it will turn in a radius of 21 ft. The minimum road clearance is 12 in.

The boiler is always one of the most interesting features of steam road vehicles, and the design evolved by Messrs. Fowler & Co. is clearly shown in Fig. 1. It is built entirely without stays, so that no trouble can occur due to breaking or leakage of stays, and their absence promotes freedom of circulation. The tube-plates of the firebox and smokebox are pressed to a spherical shape so that they are self-supporting and do not exert any tension on the tubes, which are expanded into them. The water-level is well above the upper ends of the tubes, so that the latter are always submerged and are thus protected from overheating. There is, moreover, no risk of the crown of the firebox or the tubes becoming uncovered with water and overheated when the vehicle is working on a hill, and thus one of the dangers of the locomotive type of boiler is eliminated. The belt round the top of the boiler gives a large evaporating surface at the water-level, and also a large steam space, two features which tend to prevent priming when the boiler is forced. The provision of the belt has also the further effect of increasing the volume of the water at the water-line, so that the sudden fluctuations in water level which are often a source of anxiety to drivers are minimised. The boiler is fired through the central vertical shoot, which passes through the smokebox. Surrounding this shoot in the smokebox is a superheating coil which takes steam from the steam-belt and delivers it to the engine in a superheated condition. The boiler is fed by a slow-running pump driven from the transmission gear and arranged for use whether the vehicle is running or standing. An injector and water-lifter are also provided. The boiler has a grate

VERTICAL DUPLEX OIL-FUEL PRESSURE PUMP.

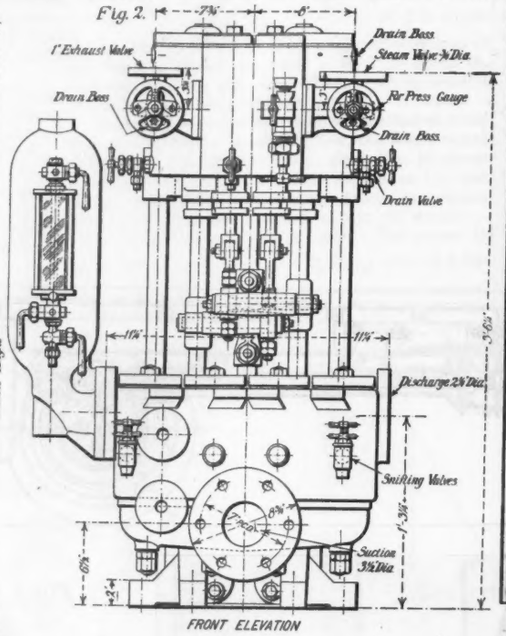
CONSTRUCTED BY MESSRS. WORTHINGTON-SIMPSON, LIMITED, ENGINEERS, LONDON.

Fig. 1.



END ELEVATION

Fig. 2.



FRONT ELEVATION

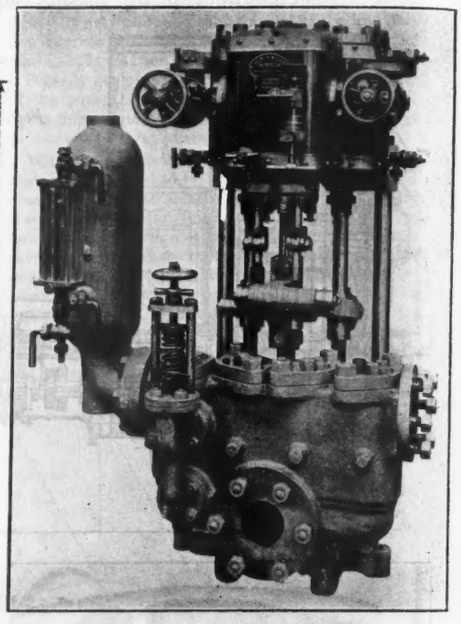
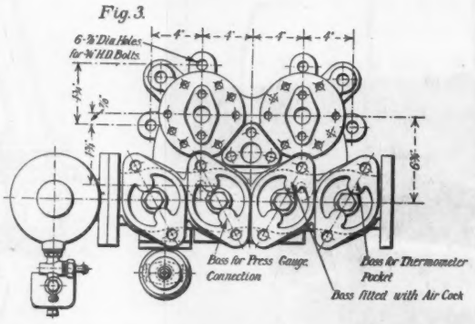


Fig. 4.

Fig. 3.



area of 3·8 sq. ft., a heating surface of 85 sq. ft., and a superheater surface of 21 sq. ft.

A compound Vee-type engine is fitted, with cylinders 4¾ in. and 7 in. diameter by 8 in. stroke. The engine is placed under the driver's seat. It is quite accessible and asbestos lagging prevents the heat causing discomfort to the driver. Both cylinders are fitted with piston valves and work on a common "big-end," giving the shortest and stiffest possible design of crank-shaft. The bearings of the crankshaft and big end are of the roller type to minimise friction and eliminate the necessity for attention. The exhaust steam is passed up the chimney, but is previously heated in a chamber surrounding the fuel shoot, so that it escapes invisibly instead of in a dense white cloud. The arrangement also acts as an efficient silencer and furthermore promotes a steady and uniform blast so that sparks and smoke are not projected from the chimney.

The gear-box, which forms an integral part of the crank-case, gives three running speeds, so that the full power of the engine can be exerted at all speeds of the vehicle. The fast speed allows the vehicle to travel at 12 miles or more per hour without running the engine unduly fast, while the slow emergency speed is invaluable when the wagon in in a difficult place. Power is transmitted to the back axle by an overtype worm drive, totally enclosed and running in oil. This will run for months without the replenishment of the oil or other attention, and the arrangement gives a good ground clearance.

A section through one of the front wheels is given in Fig. 3. The stub axle, as will be seen, is pivoted about a line passing through the wheel track, the construction being very strong mechanically and also enabling the wheel to be steered with the smallest effort. The front wheels are 3 ft. in diameter with single tyres, and the back wheels 3 ft. 5 in. in diameter with twin tyres.

The Fowler steam wagon is fitted with either a platform or a box body, to suit requirements. It is also supplied with a tipping body, to tip endways, to either side, or all three ways, the tipping mechanism being either hydraulically or screw-operated. The water tank carries 160 gallons of boiler-feed water, which suffices for a long run owing to the efficiency of the superheated steam engine. Six cwt. of coal can be carried in the bunkers. The lubrication of all working parts is automatic, the mechanical cylinder lubricator being the only one requiring daily attention. The driver is provided with a comfortable seat with a clear view of the road. All controls are arranged for easy handling and this, together with the simplicity of firing, makes it easy for one man to handle the wagon under all circumstances. A foot control, like the accelerator pedal of a motor-car is fitted to regulate the supply of steam in addition to the hand control.

VERTICAL DUPLEX OIL-FUEL PUMP.

The extended use of oil as a fuel for marine boilers has led to the development of pumps suitable for handling oils of the heaviest and most viscous natures. For such work the direct-acting reciprocating steam pump might at first sight appear to be less well adapted than pumps of the centrifugal or rotary types, giving a fairly uniform flow, but the convenience which the reciprocating pump possesses of being driven by the direct application of steam pressure makes it likely to hold the field against the rotary types for a long time to come. The illustrations above show a vertical duplex pump for the delivery of oil under pressure to the burners. The makers, Messrs. Worthington-Simpson, Limited, of Newark-on-Trent and Queen's House, Kingsway, W.C. 2, have supplied a good many pumps of this type for steamship work, the equipment of a large liner requiring four or more. The steam cylinders are 4½ in. diameter and the pump cylinders 3 in. diameter, the piston stroke being 6 in. Such a pump will deliver 3¾ tons of heavy Mexican fuel oil per hour against pressures up to 150 lb. per square inch. It is suitable for steam pressures up to 250 lb. per square inch, and works at a normal speed of 27 double strokes per minute. An adjustable relief valve, clearly shown in the photograph, serves to by-pass the delivery back to the suction in case of excessive pressure, such as would otherwise occur were the burners shut off without stopping the pump. The pump body is of cast iron, the liners and pistons being of the same material, although bronze can be used throughout should this be advisable on account of the nature of the oil. Piston valves are fitted to the steam cylinders, the ordinary Worthington-Simpson duplex valve motion being used. The pump, complete with its air vessel, gauge, &c., makes a neat and compact arrangement which has been found eminently satisfactory in practice.

WIRE ROPES RESEARCH.*

Second Report of the Wire Ropes Research Committee.

Prepared for the Committee by the Reporter, Dr. W. A. Scoble.

Introduction.—After undergoing some amount of reconstruction the committee resumed its activities in 1919. A preliminary report was published in 1920.† It was decided to limit the main tests, at the commencement, to the bending of a wire rope by passing it repeatedly on and off a pulley which reversed its direction of rotation. The size of the ropes for the initial tests was fixed at 1-in. circumference. It was decided to deal with ropes each made of wire of the same tensile strength, but of various constructions and to test these on pulleys of different diameters and under several tensions for each pulley.

The Material.—The uniform quality of material adopted is specified as "special acid patent steel" of 70 tons per square inch to 80 tons per square inch ultimate tensile strength, and this was used in wire of two diameters, (*a*) 0·021 in. (with an analysis C, 0·36; Mn, 0·605; S, 0·042; Si, 0·240; P, 0·053 per cent.), specially obtained in two bundles from the mills, and (*b*) 0·036 in. from the ropemaker's stock. Messrs. Bullivant and Co., Limited, Millwall, presented to the committee ropes specially made of this material for tests.

Under test the 0·021-in. wire was found to have a tensile strength of 84 tons per sq. in., and to give 64 turns on a length of 8 in. Autographic load extension diagrams determined the elastic limit at 64 and the breaking stress at 86 tons per sq. in., with an elongation of 1·6 per cent. at fracture. The larger wire showed when tested a tensile strength of 85 tons per sq. in., and gave 87 turns on an 8-in. length. All the wire was black.

Test Ropes.—Particulars of the specimens supplied by Messrs. Bullivant are set out in Table I.

Apparatus for Repeated Bending over Pulleys.—The machine employed for the repeated bending tests is shown diagrammatically in Fig. 1, and its general arrangement can be seen from the semi-plan photograph, Fig. 3. The apparatus consists of a driving

* Presented at the Meeting of the Institution of Mechanical Engineers on Friday, December 19, 1924.

† Proceedings, I.Mech.E., 1920, page 835.

shaft, DS, belt driven by a motor. The crank C at one end of this shaft oscillates the rocking shaft RS through a connecting rod CR, and rocking lever RL. The driving pulleys DP, which are keyed to the rocking shaft, are of greater diameter than the largest test pulley. The rope under test, TR, is fastened by clips L to a driving rope DR, which causes it to move to and fro over the test pulley TP, this arrangement being used in order to reduce the length of test rope required.

TABLE I.

Nos.			
1	6 × 12 × 0·021	Lang's lay.	Strand of 12 wires round hemp core.
2	6 × 12 × 0·021	Ordinary lay.	Ditto.
3	6 × 19 × 0·021	Lang's lay.	Strand of 12 over 6 over 1.
4	6 × 19 × 0·021	Ordinary lay.	Ditto.
6	6 × 6 × 0·036	Lang's lay.	Strand of 6 × 0·036 on core wire of 0·038 iron.
7	6 × 7 × 0·036	Lang's lay.	Strand of 6 on 1, all 0·036.
8	6 × 7 × 0·036	Ordinary lay.	Ditto.

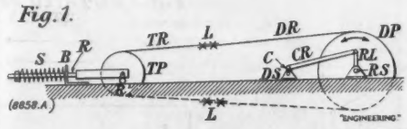
The test pulley rotates freely on a pin in a tension fitting having a calibrated spring S bearing on a fixed bracket B, and an adjusting screw and nut to enable any desired tension to be put on the rope and indicated by the spring S. The weight of the spring partly balances that of the pulley which is also supported by the tension of the rope. In the small machines used for single wires and strands, Fig. 2, the screwed adjusting rod R is given a fairly long bearing to enable it to move freely in the bracket B. In the larger machines used for the tests of complete ropes, the adjusting rod passes through a clearing hole in the fixed bracket B, and, when necessary, the weight of the pulley is supported by rollers R′ mounted in ball bearings. As the cable sometimes stretches at the commencement of a test and again when it begins to break up, and as such stretching, by reducing the compression of the spring S, diminishes the tension in the rope, a closely-set electrical contact is arranged so that any stretch causes it to close and ring a bell when the tension can be re-adjusted immediately.

Repeated Bending of Wires and Strands.—It was suggested that an attempt should be made at an analysis by which it would be possible to separate the destructive effects of outside wear, wear between the wires, and bending fatigue. With this object in view tests have been made on single wires and strands taken from, as well as on, complete ropes.

The outside wear of single wires is not likely to be serious, so that bending fatigue should be the most important cause of failures, although, if the wire twists, the plane of bending is changed and the result may be affected thereby. Stranding the wire introduces the possibility of internal wear between the wires, in addition to the bending fatigue, also the length of the actual bearing of each wire on a pulley is reduced, causing outside wear to be more important than with single wires. Laying up the strands into cable still further decreases the bearing length of individual wires on a pulley, and leads to short contacts between the wires of adjacent strands. The greater tension carried by a complete rope intensifies the pressures at the contacts, which produces an increase of wear at the regions where the strands touch the pulley and each other.

A million bends were taken as the limit for the endurance. The bend referred to was a complete cycle, the specimen being bent from the straight on to the pulley and back again to the straight. The test results for the repeated bendings of a single wire of 0·021 in. diameter over pulleys of various sizes are plotted in Fig. 4. The number withstood increased when larger pulleys were used, and the yield was in consequence smaller. The effect of direct tension was inconsiderable when a small pulley was used.

Fig. 1.



It was estimated that a wire of this size would be stressed to its tensile yield-point when bent over a pulley of 4·7 in. diameter. On pulleys smaller than this the number of bends required to produce fracture was less than 100,000, and on 5-in. and 6-in. pulleys the numbers of bends were of this order when the calculated stress was in the region of the yield-stress of the material. Contrary to expectations, it was found that at greater tensions an increased number of bends was necessary to produce fracture.

Results of Tests on Strands.—The results of the tests on strands are shown plotted in Fig. 4.

The curious phenomenon mentioned above was not repeated with stranded wires, and it is clear that either some new factor which did not apply to the single wire entered into these tests, or that some irregularity in the single-wire tests vitiated this result. In each case the tension carried by a strand for a given number of bends was greater on a large than a small-diameter pulley, and the number of bends required to produce fracture on a given pulley increased as the tension was diminished (Fig. 4).

Comparing the behaviour of the strands tested, that from Cable 1, consisting of 12 wires round a hemp core, gave the best results, the seven-wire strand (six on one) was next, with the completed strand from Cable 3 (19 wires, 12 on six on one) last, which was not found to be capable of carrying any appreciable tension on any pulley of less than 11 in. in diameter, and even then only carrying a load of 16 lb. on a wire which had a breaking load, in direct tension, of 65 lb. The strands represent the first stage in the development of a rope.

Considering their behaviour from another point of view, the "12-wire on hemp core" strand needed an 8-in., the 7-wire (central core of 19-wire strand) a 9·5-in., and the 19-wire an 11-in. pulley to withstand one million bends under a tension of approximately one-quarter of its breaking strength. These are in order of merit, and the calculated stress in the materials of the three strands, including full bending stress, required to break them at a million bends were 58, 49, and 45 tons per square inch respectively (Fig. 5), all of which are below the yield-stress of the wire, namely, 64 tons per square inch.

It was clear that considerations other than the tensile and repeated bending stresses must be taken into account, of which the most important appeared to be the action of the pulley on the wire. In these tests the wear at the contacts between the wires and pulley was negligible. The remaining factors were the lateral pressure on the wire at contact with the pulley, with an alteration of structure of the wire caused by the relative movement of the wire on the pulley under the lateral pressure.

Single wires of 0·036 in. diameter confirmed the curious repeated bending results recorded for the 0·021-in. wire, particularly the increased numbers of bends under greater tension, obtained on all the pulleys used. The curious way in which units of strands will "hang on" and improve the endurance until complete fracture occurs is well illustrated by one test of the 7-in. by 0·036-in. strand on the 14-in. pulley under a tension of 50 lb. :—

No. of Bends.	148,287	244,377	267,965	313,460	316,044	346,106	382,031
Wires broken	1	2	3	4	5	6	7 complete fracture.

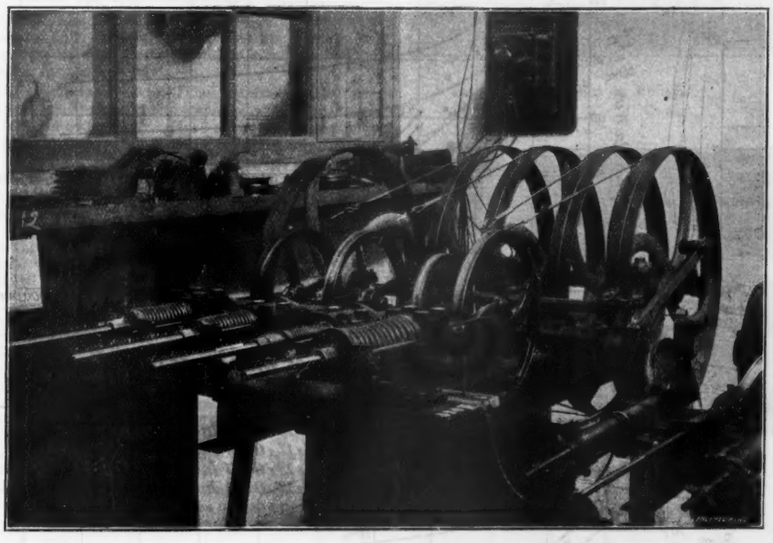


FIG. 2. SMALL MACHINE USED FOR SINGLE WIRES AND STRANDS.

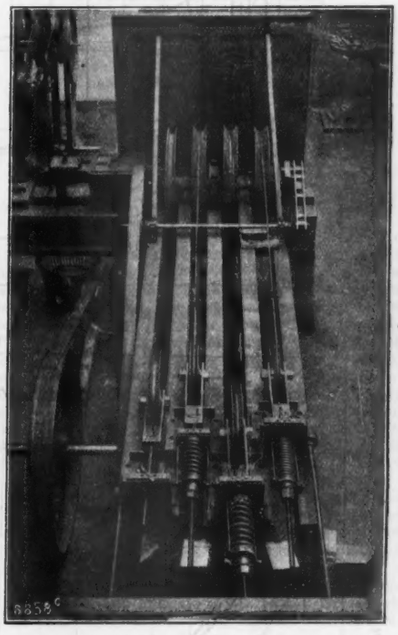


FIG. 3. MACHINE EMPLOYED FOR THE REPEATED BENDING TESTS OF CABLES.

Repeated Bending Tests of Completed Cables.—The results obtained from repeated bending tests of complete cables over pulleys are given in the Report, the stress due to tension being calculated by dividing the total tension on the rope by the cross-section area of the wires forming it (neglecting the iron core in Cable 6) and the bending stress obtained from the formula Ed/D without reduction factor.

E = Young's Modulus.
d = diameter of wire.
D = diameter of pulley.

Although the former Report showed that reduction factors as low as one-third have been recommended for use in this formula, for comparative purposes no factor was here used; nevertheless the total calculated stresses at failure were below the yield-stress of the

wire. After test the broken or damaged cables were carefully examined.

After it had been decided to use grooved pulleys and to lubricate all ropes, a cable was soaked in cylinder oil of medium consistency for at least twenty hours before it was used, and it was kept oiled under test. In the case of Cable 1 only one specimen was lubricated,* and lubrication appeared to be somewhat beneficial.

Discussion of these results presents many difficulties as they may be treated from many points of view, but the following points are indicated :—

(1) Strands formed on a hemp core in a Lang's lay rope gave the best results, and this superiority was more marked on large than on small pulleys, while Lang's was no better than ordinary lay for the ropes of 19 wire strands.

(2) The fractions of the breaking tensions in these Cables, 1 to 4, necessary to cause failure after one million bends on the 14-in. pulley were, approximately, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{10}$, and $\frac{1}{5}$ respectively, yet this pulley had a diameter three times that which was calculated to give yield point stress indicating superiority of Lang's over ordinary lay. On the 14-in pulley, No. 6 carried the highest load, indicating an advantage of the soft core under severe bending conditions, while (allowing for the slightly larger pulley used for No. 8) Nos. 7 and 8 showed that there was not much difference between Lang's and ordinary lay in the 6 by 7 construction on this size of pulley, where stresses due to bending were apparently responsible for fracture.

The smallest pulley used with these ropes was of 10-in. diameter. On this the advantage of the soft core was maintained, while ordinary lay, about equal to Lang's under high loading and short life conditions, became decidedly superior thereto at the "greater endurance" end of the curves. The total stresses on the wires produced by the direct tension and the bending were

Fig. 4. REPEATED BENDING OF WIRE ROPES OVER PULLEYS. COMPARISON OF SINGLE WIRES AND STRANDS.

——— *Single 0·021 Inch Black Wire. 84 Tons per Sq. Inch*
– – – – *12 x 0·021 Inch Strand, round Hemp Core*
—·—·— *7 x 0·021 Inch. 6 over 1. Centre of 19 Wire Strand*
····· *19 x 0·021 Inch Strand. 12 on 6 on 1.*

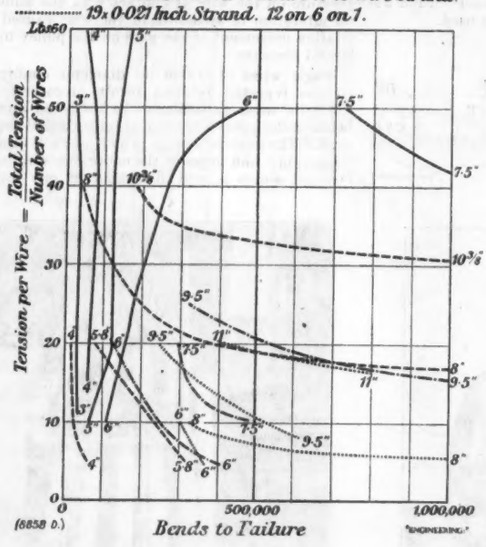


Fig. 5. REPEATED BENDING OF WIRE STRANDS OVER PULLEYS. STRESS AND BENDS TO FAILURE.

12 x 0·021 Inch on Hemp Core
7 x 0·021 Inch Centre 7 Wires
19 x 0·21 Inch.

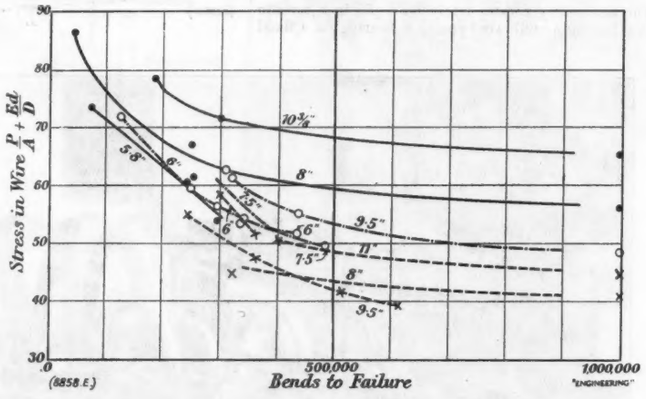


Fig. 8.

Groove Lubricated
" not Lubricated
As Cast " "

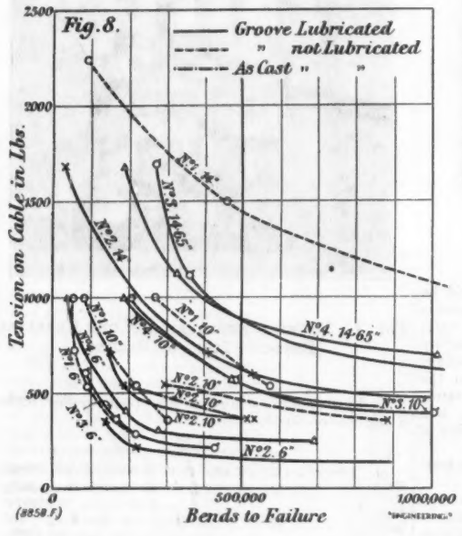


Fig. 9. REPEATED BENDING OF WIRE ROPES OVER PULLEYS

Strand 12 x 0·021 Inch on Hemp Core.
19 x 0·021 Inch.
Cable No. 1. 6 x 12 x 0·021 Inch Lang's Lay.
" No. 2. 6 x 12 x 0·021 Inch Ordinary Lay.
" No. 3. 6 x 19 x 0·021 Inch Lang's Lay
" No. 4. 6 x 19 x 0·021 Inch Ordinary Lay

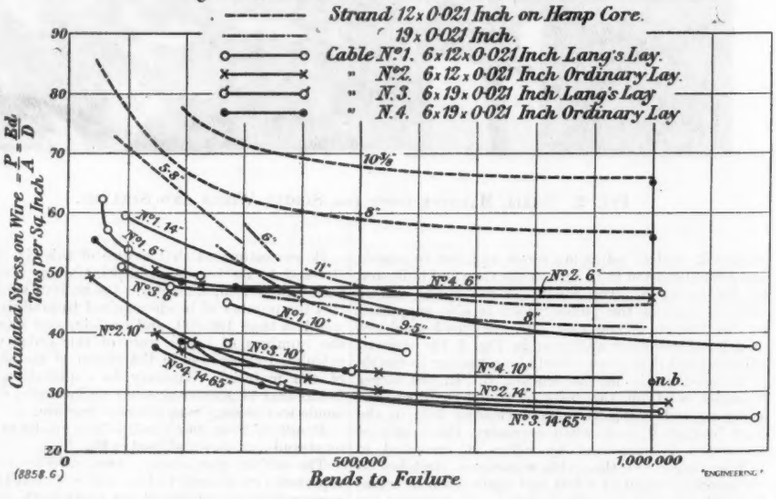


Fig. 8. Repeated Bending of Wire Ropes over Pulleys.

No. 1 Cable. 6 × 12 × 0·021 in. 84 tons per sq. in. Lang's lay. Black wire. Hemp cores in strands and rope.
No. 2 Cable. 6 × 12 × 0·021 in. 84 tons per sq. in. Ordinary lay. Black wire. Hemp cores in strands and rope.
No. 3 Cable. 6 × 19 × 0·021 in. 84 tons per sq. in. Lang's lay. Hemp core to rope.
No. 4 Cable. 6 × 19 × 0·021 in. 84 tons per sq. in. Ordinary lay. Hemp core to rope.

Here also the use of pulleys with grooves fitting the cable markedly improved the endurance. With the ordinary lay Cable 2 the advantage of the correct groove was not so evident. Unexpectedly, the lubrication of the rope reduced its endurance.

The results obtained from all the cables of 0·021 in. diameter wire are plotted in Figs. 8 and 9.

* Additional tests were made after the Report was commenced.

in a wire bent round it, so that tests on still larger pulleys appear to be desirable.

It should be noted that although the stresses plotted in Fig. 9 include the full bending stress for the wire; the stress values which cause failure at one million bends are all below yield-stress. In general, this stress thus carried for one million bends is greater on small than on large pulleys (which may indicate that the bending stress has been given too much weight in the method of calculation), being 46–47 tons per sq. in. for the 6-in; about 32 tons for the 10-in.; and 26–28 tons for the 14-in. pulley, results which are consistent except for Cable No. 1 on the 14-in. pulley, which carried 38 tons per sq. in.

The wire and strand tests had indicated that pulleys of 14 in. or less in diameter were too small to carry Cables 6, 7 and 8, and this appeared to be confirmed by the behaviour of the entire ropes. On the 17·5-in. pulley Rope No. 7 was superior to No. 6, even on a tension per wire basis, showing the soft core to be a disadvantage; while No. 8 was worse than either, between 41 and 51 tons per sq. in. for the maximum endurance.

Effect of Size of Wire.—On the 14-in. pulleys the large wire cables were superior to small wire ones under long endurance conditions, while on pulleys having a diameter suitable for the wire diameter, they were immensely so. The large wire cables failed rather badly on 10-in. pulleys, thus giving another indication that the critical diameter for cables of 0·036 in. wire is in the region of 14 in.

Progress of Failure : Broken Wires in Rope.—In the hope that some evidence would be obtained which would help to decide when the borders of safety were being reached, the progress of failure of the test specimens has been noted. Two parts of each loop of cable were under test, that is, that running on and off at the top of the pulley, the other at the bottom, and in one of these portions the broken ends (two ends indicating one broken wire) were counted at intervals and recorded against the bends which had taken place. No intelligible conclusions appear to be possible from these tests

and the data are included in the Report for those who may be interested. The behaviour of a cable seems to depend on its construction and the severity of the treatment it receives.

The Distribution of Broken Wires.—It was thought that helpful evidence might be obtained by observing the *positions* of the wires in the cable as they broke. No general law can be found relating to location of the wire fractures.

The Determining Features which Caused Fracture.—In the broken ropes the types of fractures noted were: (1) the inclined break indicating brittleness caused by repeated bending, and (2) the cup-cone "tension" type of failure. Brittle fractures were found in every rope examined, thus indicating that bending was an important factor in the cause of failure.

Discussion of Other Destructive Effects.—(*a*) *Small Wire Cables,* Nos. 1, 2, 3 and 4. (1) *On Small Pulleys, 6-in. diameter.*—The calculated maximum stress, that is, direct tensile stress plus the full stress due to bending, was from 46 tons to 48 tons per square inch, Fig. 9, which is well below the yield-stress in simple tension. Although the relative movements of the strands were greater on smaller than on larger pulleys, the nicking caused by one strand on another was small to negligible in Cables 1, 2 and 3, and 4 alone showed appreciable effects of the internal working of the rope. Comparison with the results obtained from these cables on larger pulleys shows that the 6-in. pulley was too small for normal working with any of them, as it permitted only a small tension to be carried by the specimen.

(2) *On 10-in. Pulleys.*—The maximum total stress which permitted great endurance was reduced to about 32 tons per square inch. No. 1 cable showed an amount of outside wear medium to large, and serious nicking by strand on strand, each of which causes localised many of the wire fractures. No. 2 cable showed considerable nicking and small to medium outside wear when unlubricated, but each of these effected the failure of the wires. Lubrication of the cable reduced both, but the wires were broken after the same number of bends, whether lubricated or dry, at 540 lb. tension, and after less bends when lubricated under a tension of 360 lb. From this it appears that, while lubrication reduces the wear both at the pulley and between strands, it also reduces the friction between the wires and thus reduces the tension which can be carried by a broken wire. Each broken wire means a greater loss of strength in a lubricated than in a dry cable. This cable showed greater endurance on a correctly grooved pulley than on one with a large groove. It seemed that the pressure of the wire on the pulley or on another wire, combined with the direct tensile and bending stresses produced fracture. Rope No. 4 on a 10-in. pulley at a tension of 400 lb. indicated that at low tensions the lateral pressure on the wire was not so important since the wire fractures were not confined to the regions of outside wear.

(3) *On 14-in. Pulleys.*—The wear of the wires was considerable in Cable No. 1, which was apparently weakened by this cause, but no such result was noticed in Cables Nos. 2, 3 and 4.

Maximum Tensile Stress Carried.—Cable No. 1 was superior in this respect to the other three which were, approximately, equal. This feature increased with the increase of size of pulley.

Effect of Lay.—The cable of Lang's lay, with a fibre core to the strand, gave the best results on the large pulley, although, exceptionally, the 19-wire strand of this lay showed no superiority over one of ordinary lay.

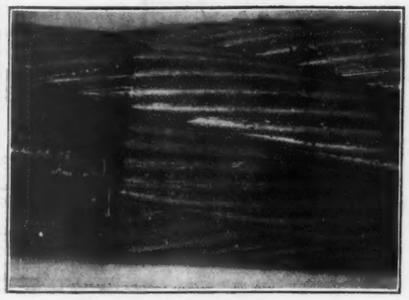
(*b*) *Thick Wire Cables, Nos.* 6, 7 *and* 8.—These cables were all of 6 by 7 construction, No. 6 having a core wire of 0·038-in. iron to each strand (Lang's lay); No. 7 and 8, 0·036-in. wire throughout; No. 7, Lang's; No. 8, ordinary lay. The comparisons were intended to show the effect of the soft wire core and the difference between Lang's and the ordinary lay.

(1) *On 10-in. Pulleys.*—The maximum tensile stresses for the three cables were nearly equal at, approximately, 51 tons per square inch:—(*a*) The soft wire core did not, apparently, improve the cable; (*b*) Lang's lay did not appear to be superior to the ordinary lay.

Wear of Wires.—The nicking of strand on strand was negligible, probably because the tensions used were very small indeed. Outside wear was small or medium for Cables Nos. 6 and 7, and less for Cable No. 8, although this was the only rope on which it localised the fractures of the wires. This indicates that the maximum tensile stresses for the Lang's lay cables were below the yield stresses owing to an unequal distribution of tension among the wires when the cable was bent over the pulley or that at low tensions on small pulleys the cable does not bed properly in the groove, and thus secure the full benefit of the longer bearing which Lang's lay should give.

(2) *On Medium-sized Pulleys: Wear of Wires.*—Nicking of wires was small in each case and outside wear only medium in amount. It is worth while noting that:—(*a*) The outside wear on Cable No. 6 did not always determine the position of fracture. (*b*) The results for Cable No. 7 were low, because the specimen broke at one side of the pulley, but showed little damage on the other; a check test, at a tension of 840 lb. made subsequently, confirmed this. (*c*) The low results given by Cable No. 8 appear to show the advantage of Lang's lay, as in this case the wires fractured at the point of maximum outside wear.

The maximum tensile stress for No. 5 Cable was 45 tons compared with 41 tons per square inch for



Cable not on Pulley.

Cable on 11-In. Grooved Pulley.

Cable on 6-In. Pulley.

FIG. 21. RELATIVE MOVEMENT OF STRANDS OF A ROPE WHEN PASSING OVER A PULLEY.

No. 8. The soft wire core on No. 6 was nicked and broken, and its use seemed to be of little, if any, advantage.

(3) *On 17·5-in. Pulleys.*—The maximum tensile stress for No. 7 increased to 51 tons per square inch when used on this pulley.

External Wear.—Cable No. 8 showed greater wear of wires and nicking, and this accounted for its inferior behaviour, in this case showing the superiority of Lang's lay cable, particularly without a soft core to the strand.

THE HARDENING OF WIRE BY REPEATED BENDING.

Hardness Tests.—Indentation tests showed that repeated bending produced a distinct hardening of the wire, and that the degree of hardening was greater as the tension on the wire when undergoing repeated bending, was increased. A method recently described by Dr. Haigh was used in which two wires, placed one across the other at right-angles, were subjected to pressure which caused each to indent the other, thus, by the indentation produced, indicating their hardness.

Torsion Tests of Wire.—After repeated bending, torsion tests of wire gave the following results on a 2-in. length:—

	Turns.
Piece broken out of Cable No. 7, 10-in. pulley, 600 lb. tension, after fracture (wire had broken in two places)	24
Piece broken out of Cable No. 6, 10-in. pulley, 600-lb. tension, after fracture (wire had broken in two places)	23, 24
Piece broken out of Cable No. 8, 14·65-in. pulley, ¼-ton tension, after fracture (wire had broken in two places)	22
Single 0·036-in. wire broken on 12-in. pulley, tension 50 lb.	
(1) Length next to fracture....	1
(2) ,, ,, (1)	17
(3) ,, ,, (2)	26
(4) ,, ,, (3)	23
(5) ,, ,, fracture (other piece)	3
(6) ,, ,, (5)	26
7 × 0·036-in. strand of Cable 7, 12-in. pulley, tension 140 lb. All brittle fractures, slight outside wear. Core wire slightly nicked at a few places. Appreciable marks of bearing on core and of outer wires on each other.	
Core wire near fracture	21
,, piece next to above	21
Outer wire near fracture	21, 23
Strand 12 × 0·021 on hemp core, 5·8 in. pulley, tension 180 lb. Brittle with two tensile fractures. Medium, uniform, outside wear. Lengths next to fracture	3, 20, 2

From these results it appears that the hardening of the wire only becomes apparent in a torsion test after it has been bent as a single wire or strand. Brittleness was evident from some of the results, but it was local in the cables, and, therefore, not shown by torsion tests on 2-in. lengths taken from between fractures. It appeared that some sections of the wire were more subject to brittleness under repeated bending than others.

Effect of Bedding.—Cable No. 8 was run on an 18-in. pulley lined with raw hide, and its improved behaviour illustrates the benefit to be derived from the softer bedding; therefore, showing that the low results obtained on the 17·5-in. steel pulley were due to intense pressures on a short bearing length.

The Relative Movement of the Strands of a Rope.—Dr. H. S. Hele-Shaw, when Chairman of the Committee, suggested that the relative movements of the strands of a rope should be studied as it passed on to and left the pulley.

In order to do this a portion of rope was blackened up to a section normal to its axis. Photgraphs were then taken of the rope, Fig. 21, looking down on it, in its groove, the rope tested in this way being one of 6 by 19 ordinary lay. From the photographs it will be seen that the movement of a strand with respect to that next to it varied from abou thalf a wire diameter over an 11-in. pulley to one wire diameter for the 6-in. pulley. The diameter of the wire is about one-fifth of that of the strand and one-fifteenth that of the rope.

Summary.—Single wires tested by repeated bending over pulleys gave unexpected results, standing more bends under greater tension.

The calculated stresses in strands, at which they endured a million bends, were, taking the full bending stress, 58 tons per sq. in. for 12 by 0·021 on hemp core, 49 tons per sq. in. for 6 on 1, and 45 tons per sq. in. for 19 wires, 12 on 6 on 1. The yield stress of the wire was 64 tons per sq. in. From this it appears that the bearing pressure between the wire and pulley is important in the case of strands.

Lubrication of a cable was slightly beneficial in one case when the conditions were severe and the cable had a short life, but generally lubrication reduced the life of a rope. A correctly grooved pulley gave a longer life to a Lang's lay cable than it had on a large score pulley, but the benefit was not so marked with an ordinary lay rope.

A hemp core to a strand proved an advantage, particularly when associated with Lang's lay. A pulley diameter of about three times that which gave the yield stress in a single wire bent over it was required to differentiate fully between the cables of 0·021-in. wire. The calculated stress, tension and bending, which permitted a large endurance, depended on the pulley diameter, but it was always well below the yield stress of the wire.

Lang's lay showed no advantage with the 19-wire

SIMPLE ARTICULATED LOCOMOTIVE: CHESAPEAKE AND OHIO RAILROAD.

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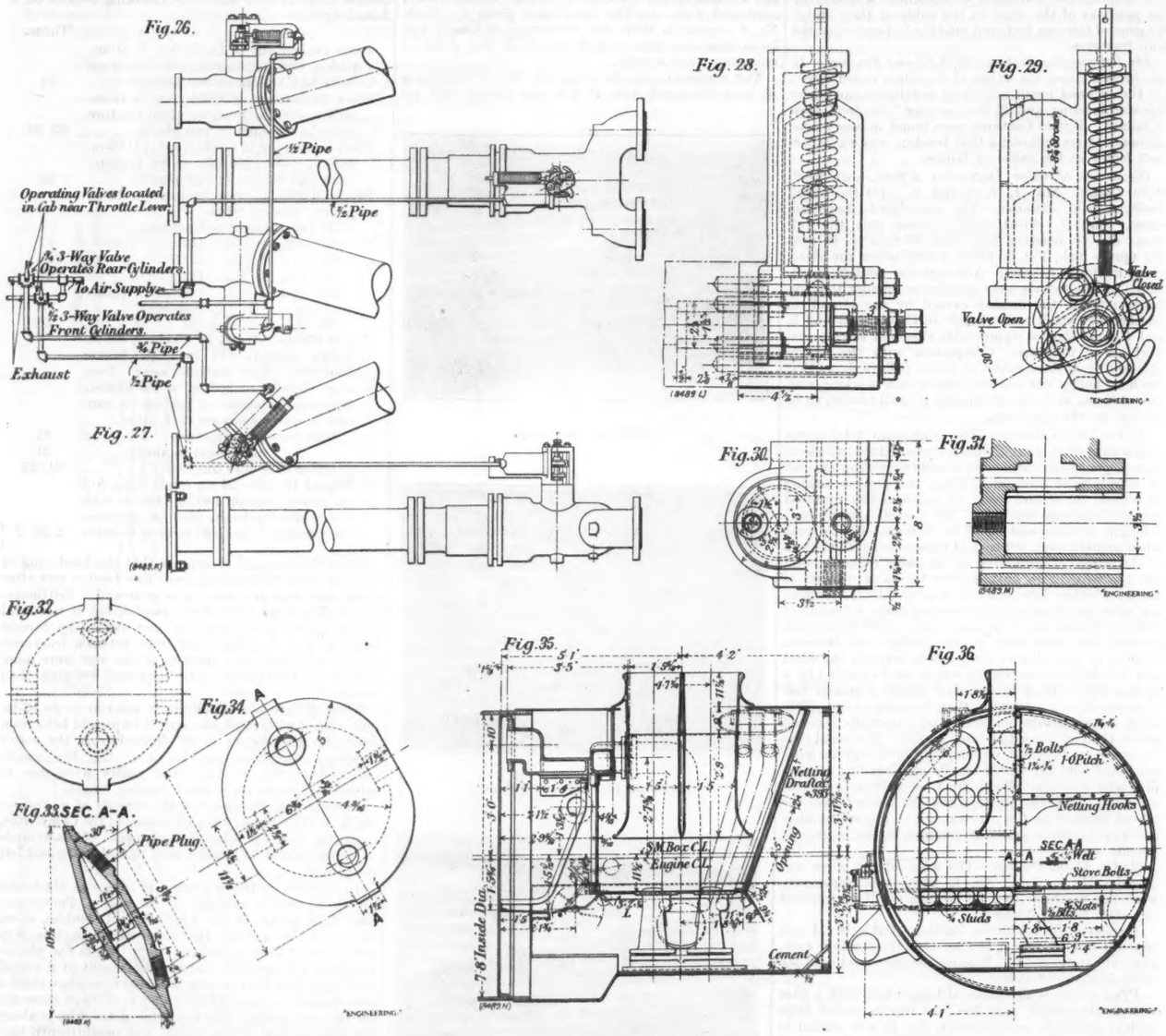


strand. A soft core wire in the 7-wire strand proved a disadvantage on a large pulley. Lang's was better than ordinary lay for the large wire cables on a large pulley, but there was little difference on the smaller pulleys. The large wire cables worked at a higher calculated stress than the 0·021-in. wire ropes, but it was below the yield stress. The larger wire cables were superior if the pulley diameter was adjusted to that of the wire.

The useful life left in a rope cannot yet be predicted in general terms from a record of wire breakages. If the working conditions be specified, it might be possible. The work done in moving a cable round a pulley bears no relation to the endurance.

The occurrence of brittle wire fractures in all test specimens showed that bending fatigue was an important factor in the failure of all ropes over pulleys.

Wires fractured most frequently at contact with the pulley or where adjacent strands touched. Only on very large pulleys, which permitted a rope to carry a high tension for a considerable number of bends, were the wires so worn that the reduction of their sectional areas appeared materially to assist fracture.

Junior Institution of Engineers.—Dr. Alexander Russell has been elected President of the Junior Institution of Engineers, of 39, Victoria-street, London, S.W.1, for the session 1924–25. His inaugural address will be delivered at the Royal Society of Arts on Wednesday, January 7, 1925.

2-8-8-2 TYPE SIMPLE MALLET LOCOMOTIVE FOR THE CHESAPEAKE AND OHIO RAILROAD.

(*Concluded from page* 798.)

The adoption of four high-pressure cylinders, instead of the more general arrangement of compounding, somewhat complicates the steam distribution. In the usual Mallet design, high-pressure steam has to be led only to the cylinders on the main frame, whence low-pressure steam is taken through a flexibly-jointed pipe to the low-pressure cylinders on the articulated frame. In the present instance, high-pressure steam has to be delivered to the cylinders on both the main and articulated frames, and provision also has to be made for the exhaust from both sets. The arrangement of piping is as follows:—From the high degree header in the smoke-box, a large branch is led down on each side and taken out through the smoke-box side plating, as shown in Fig. 36. From this point, on each side a 9½-in. steam pipe runs back to the steam chest of the rear cylinders. In a similar manner the exhaust from each of these cylinders is carried forward to the smoke-box in 9½-in. pipes, just underneath the steam pipes. Sections of these pipes are shown in Figs. 15 to 20, while the arrangements at the front end are well shown in Figs. 21 and 22, on pages 796 and 797 of our issue of December 12.

From the two main steam pipes steam is supplied to the steam chest of the back pair of cylinders and also to a central chamber in the saddle (Figs. 15 and 16), and from here it is carried forward through a single pipe fitted with flexible joints to the cylinders on the articulated frame, where it is branched, and the steam delivered to separate passages leading to the front steam chests. The exhaust from these cylinders is carried to the smoke-box and blast pipe through two pipes fitted with flexible joints. Figs. 26 and 27—which show the two exhaust pipes from the back cylinders, and the main steam pipe leading to the front cylinders—will assist in making the arrangement clear though they are actually given to bring out other points to which we shall refer below.

Reference to Figs. 15 and 16, page 796 *ante*, will show that the rear cylinder castings are not symmetrical, the joint being to one side of the centre line. This enables the joint for the steam pipe to the front of cylinders to be kept central and directly above the articulation pivot, without being traversed by the joint between the cylinder castings.

The four cylinders, which are all 23 in. by 32 in., are fitted with piston valves with 1 in. outside lap, no inside lap, and ¼-in. lead in full gear. The piston rods are 4½ in. in diameter, the pistons being fitted with snap rings. Reversing is by Alco type E power reversing gear, the valve gear being of the Walschaert type. An interesting feature in connection with the supply of steam to the cylinders is the introduction of dampers in the exhaust pipes of the rear cylinders and main steam pipe to the forward

SIMPLE ARTICULATED LOCOMOTIVE; CHESAPEAKE AND OHIO RAILROAD.

CONSTRUCTED BY THE AMERICAN LOCOMOTIVE COMPANY, ENGINEERS, SCHENECTADY, N.Y., U.S.A.

Fig. 37.

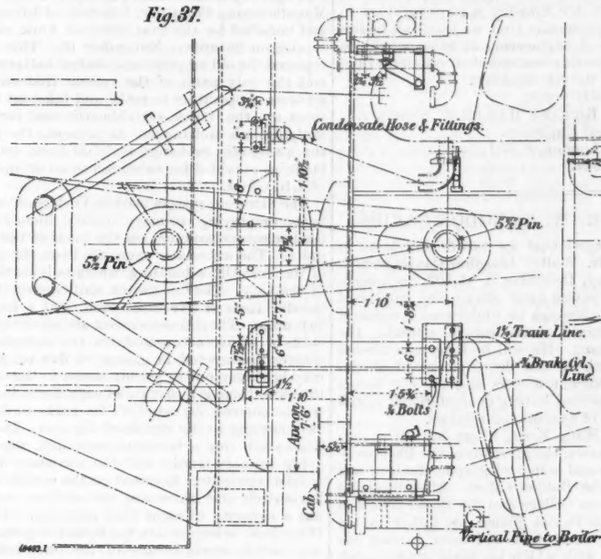


Fig. 38.

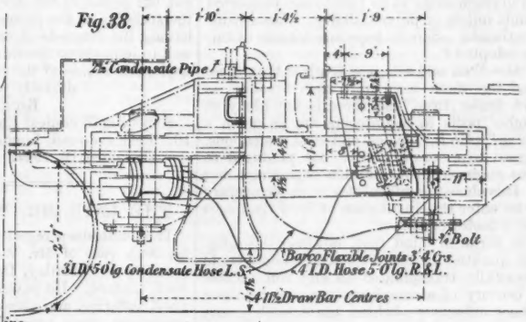
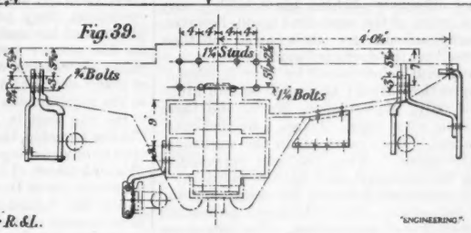


Fig. 39.



cylinders. This arrangement is illustrated in Figs. 26 to 34, opposite. These dampers are for use in the event of either set of engines slipping, and by means of them it is possible in the one case to raise the back pressure temporarily, and in the other to diminish the supply of steam so that either engine can be controlled from the cab to arrest slipping in starting or at other times. The dampers used in the pipes are shown in Figs. 32 to 34, Fig. 32, being a projected elevation of a damper in its diagonal position in the pipe. The dampers are mounted on horizontal trunnions, a stuffing-box being provided on one side of the pipe through which the spindle is carried to the control gear. The latter consists of a single-acting air cylinder shown best in Figs. 28, 29 and 31. Fig. 30 is a detail showing the holes for the bolts fixing it to the pipe boss. The piston of the air cylinder has a piston rod in the form of a short bar rounded at both ends. One end rests in a conical seat in the piston and the other in a small pocket on a short double-ended lever on the throttle spindle. The opposite arm of this lever is under adjustable spring pressure, the latter being provided to re-open the damper on the air control cock being switched over to exhaust.

The drawings of the smoke-box show the engine to be furnished with two chimneys in a single casting. Each is 17 in. in diameter, long petticoat extensions being fitted to permit of low blast pipes. The engines are fitted with feed water heaters placed horizontally in front of the smoke-box, as shown in Fig. 2, on Plate LXXXI, given with our issue of December 12. The photograph reproduced in Fig. 1, is a view of one of the first three engines which were not so fitted. The feed is normally delivered to the boiler by two 9½ in. by 6½ in. by 10 in. Westinghouse single-cylinder direct-acting pumps, placed on the side of the boiler. The two pumps on the smoke-box front are for the air-brake. The feed pumps draw from and deliver to a single line of pipe, in parallel, but the steam end of one pump is controlled by the other. The latter has the usual rocking valve gear; the second pump obtains its steam through pipes leading from ports uncovered by the piston of the first pump cylinder. The arrangement provides for the pumps working out of phase, instead of simultaneously, and a more uniform supply to the boiler results. Hancock injectors are also provided as stand-bys on the right side of the engine.

The driving wheels are 57 in. in diameter, the cast steel centres being 50 in. in diam. The leading wheels are 30 in. in diam. and of the rolled steel type. They are fitted in an "Economy" pony truck. The trailing wheels, 42 in. in diam. and with cast-steel centres, are arranged in a "Delta" trailing truck, with outside journals, cast-steel frames and inverted heart-shaped radial bearers. This type of trailing truck was fully illustrated in ENGINEERING, vol. cxvi, page 27. The arrangement can be fairly well understood from Figs. 2, 11 and 12 of our issue of December 12.

The tender is of the cylindrical tank type, and has a water capacity of 12,000 gallons and can carry 13·5 tons of coal. The tank is carried on an underframe of cast steel and the bogie frames are of similar material.

The drawgear arrangements and pipe connections between the tender and engine are shown in Figs. 37 to 39. The main drawgear at this point consists of two bars, 7¾ in. by 4½ in. in section.

The chief particulars of the locomotive and tender are given in tabular form below :—

Locomotive :—		
Cylinders, four, diameter	...	23 in.
,, stroke	...	32 in.
Wheels, driving, diameter	...	57 in.
,, leading	...	30 in.
,, trailing	...	42 in.
Journals, main driving	...	11½ in. by 13 in.
,, other coupled	...	11 in. by 13 in.
,, leading bogie	...	6½ in. by 12 in.
,, trailing bogie	...	8 in. by 14 in.
Boiler, largest diameter	...	8 ft. 5⅞ in.
Length of tubes	...	24 ft.
Firebox length	...	18 ft.
,, width	...	8 ft. 11⅜ in.
Combustion chamber length		5 ft. 9 in.
Tubes, 2¼ in. diam.	...	278
,, 5½ in. diam.	...	60
Heating surface tubes	...	5,976 sq. ft.
,, ,, firebox and combustion chamber	...	467 sq. ft.
,, ,, total	...	6,443 sq. ft.
Superheating surface	...	1,885 sq. ft.
Grate area	...	112·29 sq. ft.
Working pressure	...	205 lb. per square inch.
Weel base, driving	...	42 ft. 10 in.
,, ,, rigid	...	15 ft. 9 in.
,, ,, total	...	58 ft. 1 in.
Weight on driving wheels	...	219 tons 4 cwt.
,, ,, leading truck	...	14 tons 5·5 cwt.
,, ,, trailing truck	...	18 tons 15 cwt.
,, engine, total	...	252 tons 4·5 cwt.
Tender :—		
Tank capacity	...	10,000 gallons.
Coal ,,	...	13·4 tons.
Wheels, diameter	...	34 in.
Wheel base	...	28 ft. 1 in.
Weight, two-thirds loaded	...	93 tons 17 cwt.
Locomotive and Tender :—		
Wheel base, total	...	109 ft. 3⅛ in.
Weight, total	...	346 tons 1·5 cwt.

LETTERS TO THE EDITOR.

THE WHITWORTH SCHOLARSHIPS.

TO THE EDITOR OF ENGINEERING.

SIR,—Several of your correspondents desire information as to H.M. Dockyard schools, and their apparent connection with Whitworth scholarships. Some genius at the Admiralty nearly a century ago discovered (what our modern psychologists are now finding out by elaborate tests, and what every teacher knows after a few months' service) that the mentality of a crowd of boys of the same age may be represented by numbers, say, − 50, 0, + 50. For nearly 90 years the dockyard schools have been worked on the basic idea of an original sifting of applicants for apprenticeships, followed by intensive training and constant weeding-out until the "plus-fifties" only are left.

In more detail, each dockyard annually selects from the local elementary schools by competitive Civil Service Examination (say) 100 apprentices to the various trades engaged in engine and shipbuilding. Selection of trade is allowed according to position on the examination list. Each apprentice attends school a few hours per week. After four years' training the 100 are weeded by examination down to say two or three apprentices. These are given a more advanced course at Greenwich, or Keyham, with ultimate employment as naval engineer, constructor or electrical engineer. The Whitworth scholars, now proving of such interest to your readers, come from the 97 or 98 "not wanted" by the Admiralty.

The dockyard schools do not exist for the purpose of training Whitworth scholars. The scholarships are open to anyone possessing the necessary technical and educational qualifications—wherever they may reside. The schools have produced regularly over this long period—from elementary schoolboys—a succession of famous ship and engine designers; Whitworth Scholars and Exhibitions with Royal and National Scholarship winners, in numbers out of all proportion (as you point out in your leading article) to the populations of these few towns.

Is this system of technical training really as good as the results indicate ?—and if so, why hasn't it been adopted elsewhere ? are questions that may be asked. First of all the Admiralty appear to be well satisfied with the scheme, and if the apprentices, for whom they have no high appointments, are good enough to annually sweep up scholarships open to the whole country, there cannot be much wrong with the system.

The second question demands more careful enquiry and perhaps tactful answering. The opinion of the writer—who has been advocating for a number of years in educational publications the more general adoption of the Dockyard school system—is that the fault lies mainly with our engineering firms. These have failed to realise that in their local elementary schools and their workshops are numbers of wasted "plus-fifties" the best latent engineering material in the world.

The President of the Board of Education, on Saturday last, at Epsom, said that :—"The value of the trained mind in many industries is not recognised . . . and that the greatest educational advances are made where the development of the school system has been clearly related to the industry or business of that area."

The history of the greater number of these highly qualified ex-apprentices is that after the dockyard shop and school training, a scholarship is held at South Kensington and a diploma obtained. This is followed by unsuccessful attempts to obtain employment in engineering with position and emoluments suitable to their qualifications. Some few obtain this, but the remainder find themselves "up against it" and drift into occupations where very often only a mere fraction of their technical knowledge is used.

If this kind of thing is to continue there is no purpose in any inquiry into the reasons for the success of the Dockyard schools. The scheme is one of the few successful applications of the much talked-of "educa-

tional ladder." Very popular on political platforms, but extremely difficult to erect! If British engineering wants men of a higher calibre, this system will provide them. Carried out logically it would mean that no one should be given the opportunity of receiving an education in engineering at an Institution supported by public funds unless of proved ability. Can anyone—however optimistic—dare to hope any scheme of this type will be adopted?

Putting "tact" on one side, the truth is that there is no demand for these men from such a source as the dockyard draws from and there is not likely to be. The higher posts in engineering are as much a "class-preserve" as in the medical and legal professions. It is a disgrace to a country that has produced so many famous engineers from humble beginnings, but it is a fact. It is almost as difficult for an ex-elementary school boy to enter the Institution of Civil Engineers as to become a doctor or lawyer.

It must be borne in mind that, however desirable, all the good qualities of the dockyard schools could not be successfully transplanted to any soil. There is nearly a century of atmosphere—success, tradition and hereditary influences—behind the schools. Any big industry or group of the same kind could, however, start a training scheme for their own and their employees' benefit on the dockyard model.

In reply to several points raised by your correspondents, the apprentices attend at school on two afternoons a week only, in workshop hours, and three evenings in their own time. Those "weeded-out" are not discharged. They carry on in the workshops on "school afternoons." They get their opportunity and benefit by the education they have received.

There is no connection between the Admiralty and the Board of Education. The Whitworth papers are not set to suit dockyard apprentices. The papers are framed by people who know what an engineer's education should be. The apprentices are given this education.

The Geometry Paper—mentioned by one correspondent—does not favour the apprentices at all. In my time (and probably now) this was one of the many subjects not dealt with in the schools. The few hours per week spent at studies are obviously insufficient for the varied, extensive and difficult curriculum.

Further classes are attended at the local technical schools and an immense amount of homework and private study has to be carried out.

This four years' combined workshop and school course is one of the most gruelling ordeals a youth can be asked to undertake. It means nearly full-time in the workshop, in addition to a course of study exceeded at few technical colleges. It is a tremendous test, mentally and physically.

In addition, up to fairly recently, the Dockyard curriculum was so entirely different from the Board of Education Examinations that we had to go through distinctly different courses for examinations in apparently the same subject.

One sympathises with Whitworth aspirants who do not live in dockyard towns. They should agitate for better educational facilities. I hope the few facts I have given will enable them to realise that the Whitworth and other scholarships are not "thrown at" the apprentices. Critics of the scheme have called it "brutally efficient" and "narrow." One can only reply that British engineering has to meet with "brutal" competition from abroad, and the Humanites won't help us very much in the struggle. Any apprentice with sufficient "savvy" to get through his dockyard and college course with distinction can usually hold his own in other activities than that of engineering.

If engineering firms will voice a demand, the municipal technical schools all over the country can supply the men, provided the teachers are given the material and allowed to use the dockyard school methods. The dockyard school teachers do not work on students of all ages, all types, all shades of ability, the sole qualification of most of them being the ability to pay a fee. The British are naturally the finest engineers in the world. At present we only use a microscopic portion of our talent.

F. G. Steed.

London, S.W. Dec. 16, 1924.

THE REMUNERATION OF TECHNICAL MEN.

To the Editor of Engineering.

Sir,—In your issue of the 12th inst. you published an advertisement from the Royal Aircraft Establishment at Farnborough, who want an assistant engineer with the qualifications of a University degree, and works and drawing office experience, offering to such a man a salary of 3*l.* a week, plus Civil Service bonus.

It must come as a shock to the engineering profession that this is what the Government has to offer in the way of salary to a highly trained and experienced member of that profession. We have taken the matter up with the Air Ministry, and have drawn the attention of the Institution of Aeronautical Engineers and the Royal Aeronautical Society to it.

Ordinarily, the two last-mentioned bodies do not, we understand, concern themselves with salary questions, but the action of the Air Ministry is so derogatory to the standing of the profession that we think all bodies having the interests of engineering at heart would do well to indicate to the Government their opinion of the deplorable action of the Air Ministry.

Faithfully yours,

Richard Hazleton, Secretary.

Society of Technical Engineers,
102, Belgrave-road, London, S.W.1.
December 19, 1924.

THE LATE MR. W. LANGDON-DAVIES.

It is with deep regret that we record the death in his 58th year of Mr. Walter Langdon-Davies, which occurred on Saturday, December 6, at 103, Inchmery-road, Catford. He passed away after many months of great suffering, and although he underwent a series of operations, they proved unavailing in arresting the progress of his malady. He will be long remembered for his pioneer work in the development of single-phase alternating current motors and for the design of many electrical devices having characteristics suited to the requirements of exceptional services.

He was born in Hong Kong, where his father, Mr. Charles Langdon-Davies, the inventor of the Phonopore system of signalling and many telegraphic devices, was Superintendent of the Bullion Office. After receiving his education at Dover College and the Royal School of Mines, Mr. Langdon-Davies joined his father in the development of his inventions and later devised the single phase motor with which his name is associated. This motor was manufactured by the Langdon-Davies Motor Company, which later became Brittain's Electric Motor Company, but was started for the express purpose of producing the new motor. In 1905, Mr. Langdon-Davies went to Vancouver and was for some years on the staff of the British Columbia Electric Railway Company. He returned to this country early in the European War and became associated with Mr. Alfred Soames in the design of special generators and transformers for use in electric arc welding, and by their efforts great progress was made in devising machines for this service. The best known appliance resulting from this combination was the Davies-Soames magnetic clutch, which is interposed between a motor and a generator and is caused to slip automatically to a greater or less extent to meet the power requirements for welding. For the development of this and their other inventions the firm of Daysohms, Limited, was founded. Mr. Langdon-Davies was a Member of the Institution of Electrical Engineers.

A Difficulty Experienced in Scandinavian Trading.—The Federation of British Industries have addressed a letter to the President of the Board of Trade on the subject of the taxation of commercial travellers entering Norway, Sweden and Denmark. In this letter it was pointed out that although the representatives of Scandinavian firms can come to this country without hindrance, the British representatives going to Denmark, to take an example, have to pay an initial licence of 400 kr. and supplementary ones of 200 kr. The raising of the fees in Norway is at present under consideration. The Federation hopes that the Government will make a strong protest against these impositions.

Trials of the ss. "Antinous."—Successful trials were made with the ss. Antinous in Belfast Lough on Thursday, December 18. This vessel was built for the New Egypt and Levant Shipping Company, Limited, of London, by Messrs. Workman, Clark and Co., Limited, of Belfast. She is of the shelter-deck type, 415 ft. in length, and has a gross tonnage of 4,560 and a deadweight of 8,400 tons. She was constructed to the requirements of Lloyd's Register of Shipping for their highest classification + 100 A.1., and is propelled by a triple-expansion steam engine, all machinery being built by Messrs. Workman, Clark & Co., Limited. There are five holds and complete shelter 'tween decks, arranged for the carriage of grain and general cargoes, and modern loading and discharging equipment has been installed on the vessel.

Contracts.—The Manchester Corporation Tramways have placed an order with the General Electric Company, Limited, for 24 40-h.p., standard box-frame, self-ventilated, interpole type tramway motors.—The Bedford Engineering Company, Crane Builders, of Bedford, have received an order from the India Store Department for two electric "Goliath" 60 ft. span travelling cranes of 5 and 15 tons capacity.—The condensing plant for the 10,000 kw. turbo-alternator to be installed at the Poplar Power Station will be of the contraflo high vacuum type, supplied by Messrs. Vickers, Limited, of Barrow-in-Furness.—The Chile Exploration Company of New York have accepted the tender of Messrs. Thos. W. Ward, Limited, of Sheffield, for the supply of 20,000 ft. of 8-in. diameter steel screwed and socketed piping to be shipped to Antofagasta.

THE AUTOMATIC TELEPHONE SYSTEM AT YORK.

The automatic telephone system, working on the Strowger system, which the Automatic Telephone Manufacturing Company, Limited, of Liverpool, made and installed for the Post Office at York, was put into service on Saturday, November 15. This installation replaced the old magneto and central battery exchanges, and the only parts of the system that still need the services of operators to make and take out the connections are the trunk switchboards and certain of the outlying sub-exchanges. At present, the capacity of the automatic exchange is 1,700 lines, but there are facilities provided for extension to an ultimate capacity of 2,100 lines.

The Strowger system used in York is of the four-digit type, employing primary rotary line-switches with final selectors mounted on the back of the line-switch units. The automatic exchange is on the ground floor of the Post Office building, which adjoins the Guildhall of the City. The line-switch units are erected in three parallel rows of five units each, and a fourth row of two units. These line-switches are mounted on shelves each of which accommodates ten switches, and the shelves are erected in groups of five on gates, which may be swung out to permit access to the cables. Over the gates there is a fuse panel with alarm fuses, through which current is supplied to each section of line-switches and to the signals of the unit. There is at the line-switch side a terminal assembly, where the outgoing primary trunks and the incoming final selector trunks terminate. Mounted on the reverse side of each line-switch unit there are two shelves, each of which has a capacity of eight final selectors. The banks of these final selectors are multiplied together, allowing any switch access to any of the lines terminating at the banks. An individual fuse panel, provided with alarm fuses, through which the current is fed to the final selectors is at the left of each shelf. On top of each line switch unit there is mounted a line intermediate distributing frame where the incoming line and meter cables terminate. On this frame the final selector banks are jumpered to the line-switches. The group selectors are mounted separately on two selector trunk boards. The selector rack is a substantial steel structure with accommodation for 240 switches, arranged in two bays of 120 switches each, and these are subdivided among six shelves. Each shelf is self-contained, and can be added to the rack when required. To provide for increase of traffic or removal for testing, switch jacks are provided on these shelves.

The other equipment of the York switchroom comprises a two-bay repeater rack, a main distributing frame, a link distributing frame and a three-bay meter rack, equipped with instruments which register effective calls only. The main batteries are in duplicate, and consist of two sets of 25 chloride cells of 9 elements in lead-lined boxes. Each battery has a capacity of 486 ampere-hours when discharged at the nine-hour rate, but the boxes will accommodate sufficient extra plates to give a discharge of 702 ampere-hours, and the extra space is at present occupied by lead displacement tanks. An enclosed ventilated shunt-wound motor operating on the 460 volts direct current supply, drives directly a shunt-wound dynamo with an output of 100 amperes at 57 volts to serve for the changing of the cells. The voltage regulation which is procurable ranges from 50 to 68 volts.

Bituminous Road Construction.—We are informed that the Asphalt Road Association, of 40, Broadway, London, S.W.1, is undertaking a considerable amount of research and technical work in connection with the use of bitumen in road construction, the object being to arrive at satisfactory standard specifications and the standardisation and simplification of sampling and testing methods. In addition, the study of sub-bases and of aggregates for use with bitumen is receiving attention as well as the question of relative costs. It is intended to place the information secured at the disposal of highway engineers and the co-operation of road officials is invited. These may join the body as associate members.

Street-Traffic in Berlin.—Londoners, notoriously enjoying good regulations for the street traffic though they have sometimes reason for grumbling, cannot expect to find much novelty in the new traffic regulations recently introduced in Berlin. Tramways are considered obsolete for the central districts of Berlin, as of other cities, but to abolish them would involve heavy financial sacrifices; their replacement can only be gradual. The number of spots where carriages must not stop has been considerably increased, but in some parts, as near the Potsdamer Platz, it is difficult to find parking facilities. Certain streets may only be traversed in one direction, and turning is forbidden in them. The public should cross streets only at certain corners or spots, otherwise claims for compensation in cases of accidents may be rejected. No rule has been made as to slow traffic keeping close to the kerb.

THE ROYAL METEOROLOGICAL SOCIETY.

AT a meeting of the Royal Meteorological Society held on Wednesday, the 17th inst., at the Society's Rooms, 49, Cromwell-road, S. Kensington, Mr. C. J. P. Cave, M.A., President, occupied the chair, when a paper entitled "*The Problem of Mild Polar Climates*," by C. E. P. Brooks, M.Sc., was read and discussed.

The author stated that if there were an ice-free polar ocean just warm enough to prevent freezing at the pole and with a temperature increasing southwards at a uniform rate, and if a small decrease of temperature occurred uniformly over this ocean, the first result would be the formation of a small polar ice-cap. It was shown that if the temperature continued to fall the growth of the ice-cap would become more and more rapid, until a point was reached beyond which the ice-cap would continue to grow without any further fall of temperature. This "critical temperature" was shown to be only about 0·25 deg.a below the freezing point; a fall of temperature of 0·25 deg.a would give an ice-cap with a radius of one degree of latitude, a fall of 0·3 deg.a would give an ice-cap with a radius of about 25 deg. of latitude. The "akryogenous" temperature, which the present Arctic Ocean would take up in winter if sea-water did not freeze, was calculated and was found to be about 270 deg. abs. Hence a rise of the akryogenous winter temperature by only 4 or 5 deg. would suffice to cause a mild climate in winter. On the basis of some work by F. Kerner-Marilaun it was shown that the land and sea distribution during Middle Eocene and Upper Jurassic times would give akryogenous January temperatures in latitude 75 deg. N. of 278·6 deg.a and 280·8 deg.a respectively. Since these were well above the freezing point they represented also the real temperatures. There was, therefore a meteorological basis for mild polar climates. Finally, it was shown that the Arctic Ocean had become ice-free once, possibly twice, since the Quaternary Ice Age, the second occasion falling in historic times.

PRICES OF IRON AND STEEL, 1924–25.—We have received an excellent chart due to Messrs. W. Richards and Sons, Limited, of Middlesbrough, which shows prices of pig iron rivets, castings, &c., and also steel angles, joists, rails and ships' plates, &c., from the year 1914 until the present time by means of variously coloured curves.

THE ELECTRICAL CONTRACTOR'S YEAR BOOK, 1924–25.—A collection of working rules in force throughout various parts of the country, together with other information of use to those engaged in the electrical trade, is included in the Electrical Contractors' Year Book, 1924–25, just published by the Electrical Contractors' Association (Incorporated), of 15, Savoy-street, Victoria Embankment, London, W.C.2, at the price of 2*s.* 6*d.* net.

SELF UNLOADING BULK CARGO VESSELS.—In ou abridged reproduction of the paper on "Self Unloading Bulk Cargo Vessels of the Great Lakes" presented by Mr. Henry Penton and Professor H. C. Sadler (*see* ENGINEERING of November 21) to the Society of Naval Architects and Marine Engineers at New York, we find that the expression "treble riveted watertight work" was used in column 3, page 724, in place of "three-ply watertight work," which has the significance that there are three thicknesses of material.

THE CABLE STEAMER FARADAY.—Messrs. Siemens Brothers and Co.'s cable steamer Faraday left the company's works at Woolwich on Saturday, loaded with 1,500 miles of submarine cable to be laid for the new Italian Cable Company between Cape Verde Islands and the Island of Fernando Noronha, a small island off the coast of Brazil. Messrs. Simens Brothers and Co., Limited, are now engaged in the manufacture of 1,700 miles of cable to form the continuation of this Italian company's system from Fernando Noronha south to Rio de Janeiro.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—The Council of the Institution of Heating and Ventilating Engineers offer three prizes, namely, the Lumby, Sirocco, and Greville Premiums, which will be awarded for original papers on subjects connected with the particular branches of engineering with which the Institution is concerned. Papers must be sent to the Secretary of the Institution by March 31, 1925, at 38, Victoria-street, London, S.W., from which address full particulars regarding the qualifications of competitors may be obtained.

PERSONAL.—The controlling interest in Ruths Steam Accumulator Company, Limited, of 45, Kingsway, London, W.C.2, has been acquired by the Fairfield Shipbuilding and Engineering Company, Limited, and Messrs. James Howden and Co., Limited, of Glasgow.—Messrs. George Ellison, of Perry Barr, Birmingham, inform us that Lieutenant-Colonel F. W. Foster, late of the English Electric Company, Limited, has been appointed Manager of their Branch Office at 78, King-street, Manchester.—Dr. W. R. Coode Adams, M.A., has been appointed an Assistant Lecturer and Demonstrator to Faraday House Electrical Engineering College.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The mixed conditions prevailing in the local iron and steel trades are reflected in the fact that while some works are closing on holiday account only three to four days, others will be idle, so far as actual production is concerned, for ten days to a fortnight. The buying movement which was thought to have begun in raw and semi-finished materials appears to have met with an early check, and what business is circulating is being done strictly on the basis of official quotations. Trade in pig-iron and hematites is restricted, while sales of common billets, as was the case in the past twelve months, are retarded by the importation of cheap material from the Continent. An optimistic note is still being sounded regarding New Year prospects, but it is evident that progress must continue to be slow. Closing quotations are as follow: Hard basic billets 9*l.*, soft basic billets 8*l.*, West Coast hematites 5*l.* 5*s.*, East Coast hematites 4*l.* 10*s.*, Lincolnshire No. 3 foundry iron 4*l.* 5*s.*, Lincolnshire forge and Derbyshire No. 3 foundry each 4*l.* 2*s.* 6*d.*, Derbyshire forge 4*l.*, bars 13*l.*, sheets 15*l.*—in each case per ton delivered at local works. The position in heavy engineering has improved from Sheffield's share in the receipt of substantial orders from British railways. Sufficient contracts have been booked for wheels, axles, tyres, and locomotive parts to keep individual plants busy for several months ahead, though it will be impossible to employ productive capacity fully until foreign and colonial transport development schemes take more definite shape. British corporations are in the market for manganese points and crossings and tramway fittings, and a fair range of business is passing in corrosion-resisting materials for various engineering uses. Automobile steel, magnets, and fittings continue to be the subject of large orders from engineers in the Midlands, and there is also a certain amount of business passing in rolled steel of special specification for the use of French automobile engineers. Other active lines are carriage fittings, engineers' tools, hammers, picks, files, saws and shovels.

South Yorkshire Coal Trade.—So far as house coal is concerned the year is finishing with more active conditions, due to the advent of colder weather and the necessity for securing supplies against the stoppage at the collieries. There is also a better demand for slacks of good quality, and a substantial call for bunkering coal. Export trade in best seams makes little headway, though the home demand is fairly robust. Coke of all classes constitutes a moderate market. Quotations:—Best branch handpicked, 32*s.* to 35*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 27*s.* to 32*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 22*s.* 6*d.* to 25*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 20*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 19*s.* 6*d.* to 22*s.*; Rough slacks, 9*s.* 6*d.* to 12*s.*; Nutty slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; Smalls, 4*s.* to 6*s.* 6*d.*

THE LYONS FAIR.—It is announced that the next Lyons Fair will be held from March 2–15, 1925. All raw materials and manufactured articles may be bought at this fair, at which more than 3,000 exhibitors are expected to attend. A comprehensive advance edition of the official catalogue, translated into English, may be had, price 2*s.* 6*d.* post free, from Mr. J. A. Victor, the official British representative to the Fair, of 77A, Queen Victoria-street, London, E.C.4. The Lyons Fair offers unrivalled facilities to the commercial buyer, and the representative proposes to organise parties of buyers desirous of attending it. He will be glad to give further particulars on request.

RELIABILITY OF OIL ENGINES.—At a time when it was difficult to obtain delivery of British heavy-oil engines, Messrs. Watney, Combe and Reid had a six-cylinder two-cycle submarine Diesel engine installed at their brewery. Since the brewery processes are continuous the plant is required to operate throughout the year for 24 hours each day. Under these conditions the engine has failed to give satisfaction, and Messrs. Mirrlees, Bickerton and Day, Limited, of Stockport, are replacing it with a Mirrlees-Diesel engine. The latter is to be a six-cylinder unit capable of developing 500 brake horse-power at 250 r.p.m. and will have an overload capacity of 10 per cent. Fuel valves, without packing, floating piston pins, and long connecting rods, are features of the construction, which will constitute the third Mirrlees-Diesel engine in service at the brewery.

BOILER EXPLOSION ON A STEAM LIGHTER.—A Formal Investigation under the Boiler Explosions Acts of 1882 and 1890 was held in Greenock on September 4 into the circumstances of the boiler explosion on board the lighter "Effort," which occurred on July 14 at Greenock. As a result of continued corrosion in the uptake of a vertical cross-tube boiler a piece of the plate, 3 in. by 3½ in., was blown out and steam and water from the boiler was ejected through the flue and fire-box into the machinery space at the fire-door and ashpit, and as the result the engineman lost his life. The Commissioners, Messrs. James A. Fleming and Wm. McArthur Morison, found that the corrosion was known to the owners and their manager, and that the latter, while he had attempted repairs, had not taken proper measures to ensure safety and had neglected to obtain competent advice. The boiler was not insured, nor had it received skilled inspection. The owners, Mrs. Hardie and Mr. James McNeil, of Greenock, were ordered to pay 20*l.* towards the cost of the Formal Investigation, and Mr. Daniel McNeil, their manager, was similarly fined.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—A quiet tone prevailed in the steel trade of Scotland this week, and as the year draws to a close there is little life in the trade. The demand for ship plates shows no signs of improving, and so long as the Continental plates can be landed here at the present low prices the outlook for the home producer is none too good. Structural engineers have a fair amount of work on hand, and while deliveries to them have been tolerably good the actual demand for structural sections falls a long way short of the normal output. In the black sheet trade the conditions have varied little over the week, and fairly satisfactory deliveries of light sheets have been general. The forward demand is not quite as good as it was, but enquiries both for light and galvanised sorts hold out the hope that fairly large quantities will be wanted for shipment in the early months of the new year. The outlet for the heavier gauges is still very limited. Export business in all classes of steel is not brisk, and in the meantime the prospects of an early improvement are not very good. Prices are steady and home quotations are as follow:—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; sections, 9*l.* 10*s.* per ton; and sheets, 1/8 in. to ¼ in., 12*l.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—While a feeling of confidence became very general in business circles after the election, it has failed to make any impression on the bar iron trade, and in the West of Scotland the malleable-iron works have remained very quiet. This week there has been little doing, and current requirements are all that are being specified for. In the steel re-rolling branches there is an absence of demand. The price of "Crown" bars is still 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade a dull tone is general, and orders both for the home trade and for export are very difficult to procure. Fairly heavy stocks are held at the works, and there are prospects of several more furnaces, now in blast, not being re-lighted after the holidays until such time as the demand increases. Prices are nominally without change, and the following may be taken as the current quotations:—Scottish hematite, 4*l.* 15*s.* per ton delivered at the steel works; foundry iron, No. 1, 4*l.* 15*s.* per ton, and No. 3, 4*l.* 10*s.* per ton, both on trucks at makers' yards.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—According to the Statistical Office of the Board of Trade, 3,532,870 tons of coal were shipped from the twelve principal seaports in the United Kingdom in November, of which 1,973,114 tons or 56 per cent. were exported from South Wales. The totals are amongst the lowest for the year, which was partly due to the fact that there were only 25 working days in November compared with 27 in October. Shipments from South Wales in the eleven months ending November amounted to 23,107,362 tons at 25*s.* 2*d.* per ton compared with 27,284,096 tons at 26*s.* 2*d.* per ton in the corresponding period of 1923. The November exports were 4,351 tons more than in October, but the value at 2,389,647*l.* was 47,679*l.* less, while the average price at 24*s.* 2¾*d.* showed a reduction of 6¼*d.* and touched the lowest level for the year. Shipments of large coal amounted to 1,240,167 tons valued at 27*s.* 6¼*d.* per ton, a reduction of 4¾*d.*, of through coal 32,428 tons at 20*s.* 9¼*d.* per ton, a drop of 1¾*d.* per ton, and of small coal 700,519 tons at 18*s.* 3*d.*, a fall of 2*d.* per ton. The volume and value of shipments from the different ports in November are shown below:—

From	Quantity.	Value.	Per Ton.
	Tons.	£	f.o.b.
Cardiff ..	1,230,429	1,424,008	23*s.* 2*d.*
Newport ..	320,212	378,150	23*s.* 7¼*d.*
Port Talbot ..	162,212	184,463	22*s.* 8¼*d.*
Swansea ..	260,261	403,026	31*s.* 0*d.*
Totals ..	1,973,114	2,389,647	24*s.* 2¼*d.*

The volume of shipments was slightly increased at Cardiff and Port Talbot, but the average fuels were lower by 11*d.* per ton at Cardiff, and 2*d.* at Port Talbot. On the other hand the shipments were reduced at Newport and Swansea, but the average price was increased by ¼*d.* per ton at the former port and by 7¼*d.* at the latter. Anthracite coal exported from Swansea amounted to 196,783 tons valued at 339,762*l.* or 34*s.* 6*d.* per ton, which was 10,186 tons more than in October, but the average price was 1¼*d.* less, although the 110,746 tons of smalls exported realised an average of 27*s.* 11*d.* per ton or 3*s.* 2*d.* more than in October, but the 86,037 tons of large despatched averaged 43*s.* 1*d.*, a reduction of 4*d.* per ton.

TRAFFIC ADVISORY COMMITTEE.—The formation of the London and Home Counties Traffic Advisory Committee, consisting of nineteen members, has now been completed. The personnel includes Sir Henry P. Maybury and Sir Herbert A. Walker, both of whom were appointed by the Minister of Transport, while Captain Sir William Nott Bower and Mr. J. R. Pakeman were selected by the City of London Corporation to represent it. The Metropolitan Borough elected Sir Henry Jackson and Sir Henry F. New, while the Minister of Labour chose Messrs. J. Clipp and B. Smith, M.P., to attend in the interests of the Ministry.

THE SISKIN II SINGLE-SEATER FIGHTING AEROPLANE.

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AIRCRAFT, LIMITED, ENGINEERS, COVENTRY.

(*For Description, see Page* 870.)

Fig. 1.

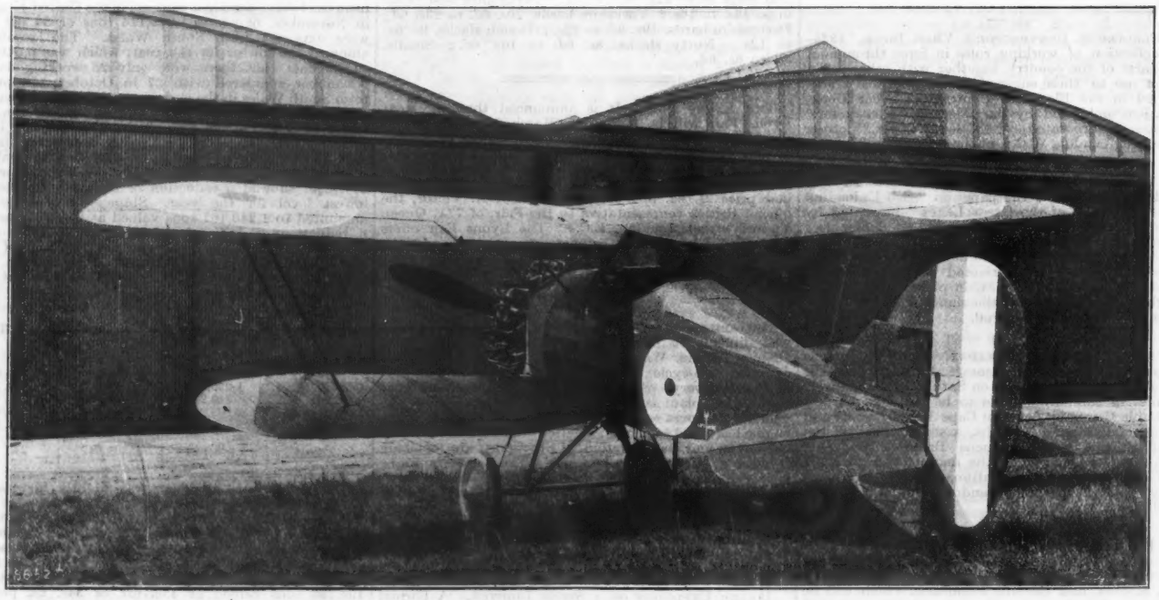


Fig. 2.

Motor Service Across the Sahara.—Little time has passed since it was demonstrated that motor traction across the Sahara desert was a practical possibility, but already a regular passenger transport service has been established. By its means it is now possible to reach Timbuctoo from London in 12 days. The inland journey starts from Oran on the Mediterranean, and from there Colomb-Bechar is reached by train. Citroën cars of the ordinary wheeled type are used for most of the rest of the journey, but in certain regions cars of the Citroën-Kegresse type, with a track-laying system for the rear wheels, are necessary. Gao, on the River Niger, a distance of 1,384 miles from Colomb-Bechar, is reached eight days after leaving the motor base, and then the journey may be continued a distance of 280 miles by car to Niamey, on the edge of the big game hunting country. Alternatively Timbuctoo may be reached from Gao by motor boats on the River Niger. This most exceptional transport service has been organised by the Citroën Trans-African Company and already full particulars may be obtained from the usual tourist agents.

International Exhibition of Hydraulic Power.—From the month of May, 1925, and extending to the month of October, an exhibition will be held at Grenoble, concerned with the development and utilisation of hydraulic power. The centre is an exceptionally good one for such an exhibition, because easily accessible from Grenoble are a large number and variety of hydro-electric and other works, so that in addition to the exhibition itself opportunities will be available for visitors to inspect working installations. The exhibition is under the patronage of the French Government and is organised by the Municipality and Chamber of Commerce. The grounds cover some 50 acres and exhibits by British firms connected with the production or application of power, and transportation, will be possible. The conditions and charges for space are obtainable on application to the Exhibition and Fairs Division, Department of Overseas Trade, 35, Old Queen-street, S.W.1. The object of the exhibition is to illustrate the great progress made in hydraulic power in recent years, and in such a neighbourhood, extremely attractive in itself, should be well worth visiting at least. It should also offer an opportunity for making our manufactures better known in Continental countries.

385-H.P. JAGUAR STATIC RADIAL AIR-COOLED AERO ENGINE.

CONSTRUCTED BY MESSRS. ARMSTRONG SIDDELEY MOTORS, LIMITED, ENGINEERS, COVENTRY.

(*For Description, see Page* 870.)

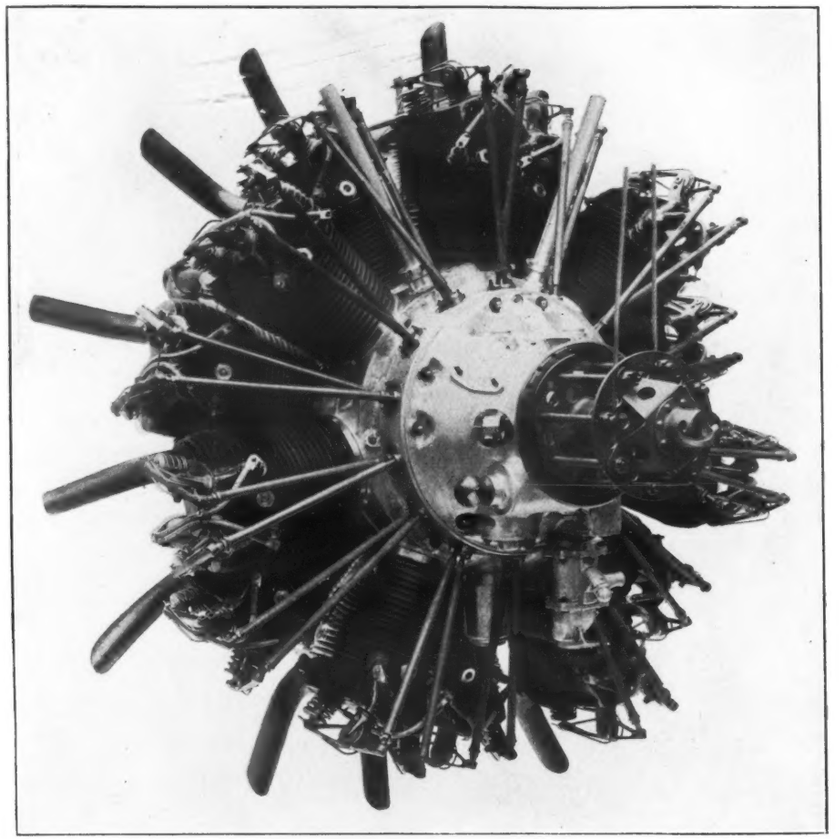


FIG. 3.

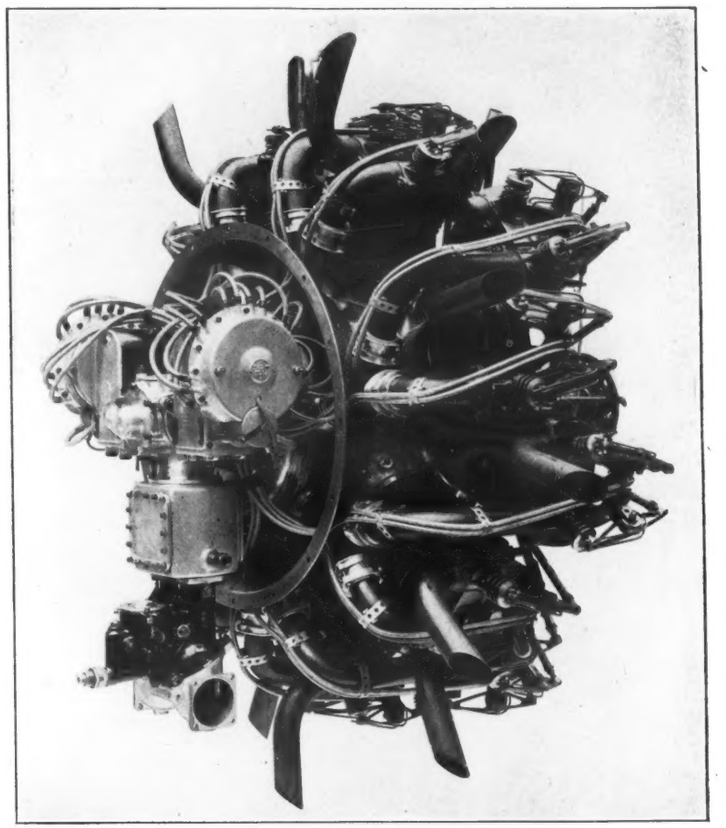
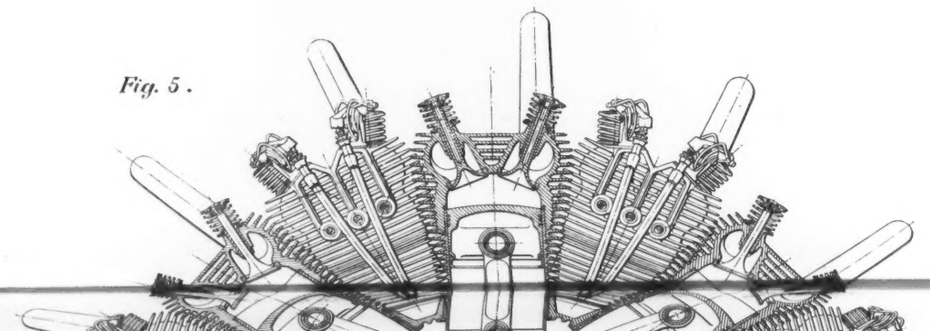


FIG. 4.

Fig. 5.



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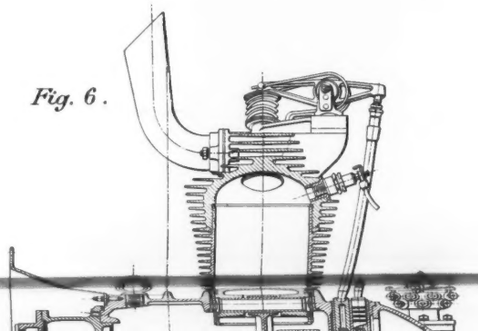

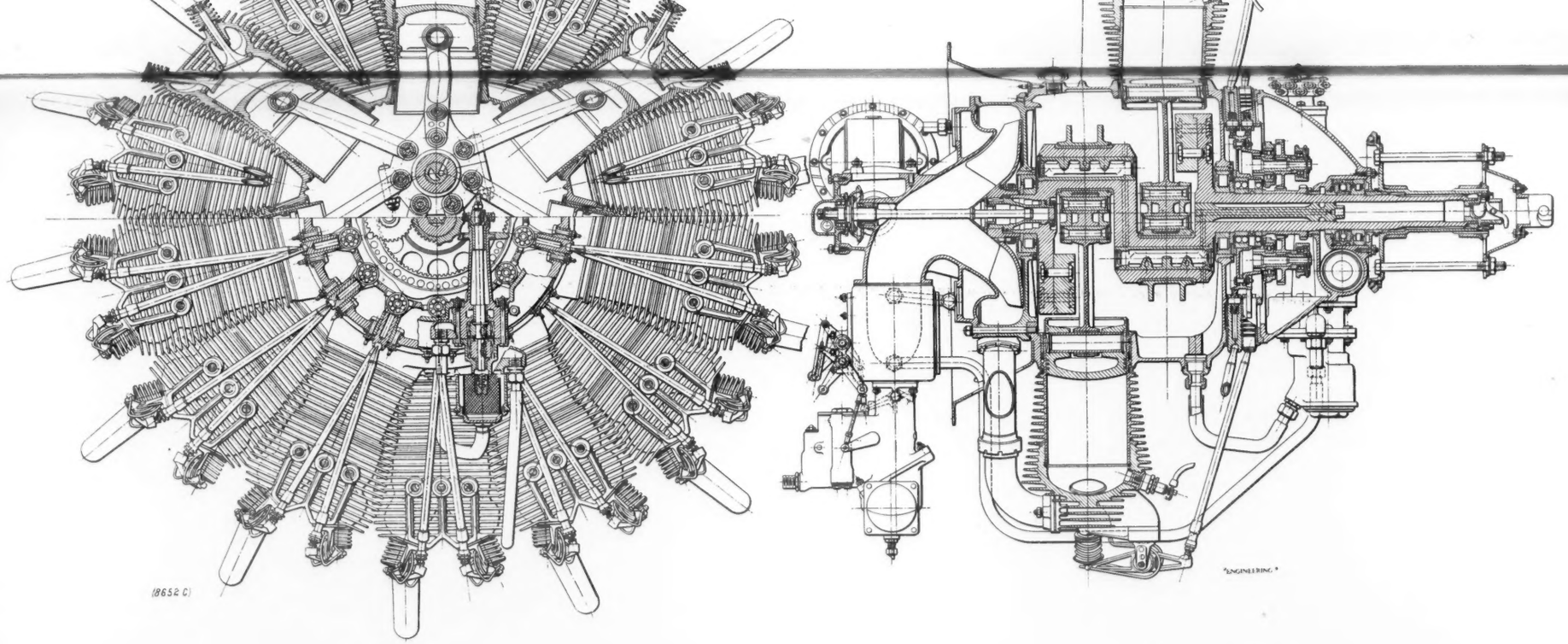

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Fig. 7.

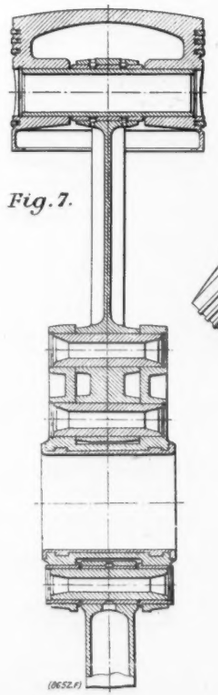

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Fig. 8.

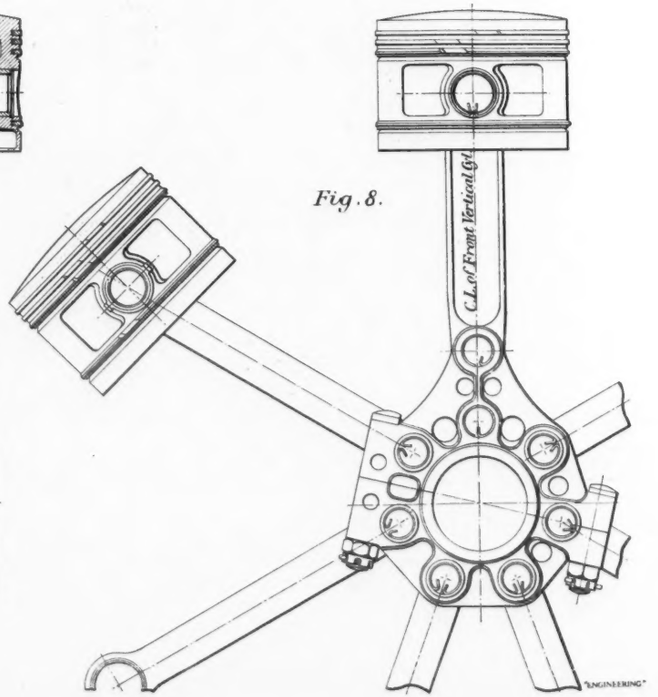

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Fig. 9.

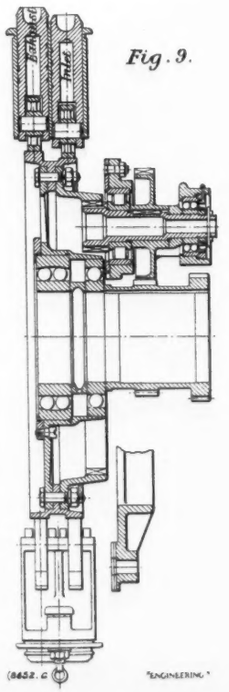

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Fig. 10.

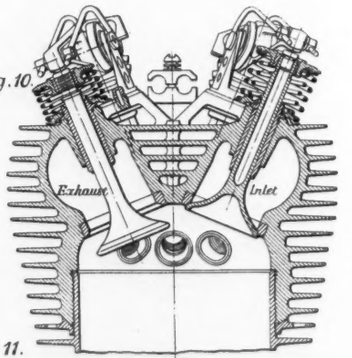
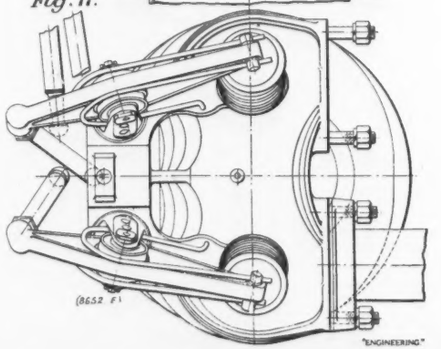


Fig. 11.



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Two-Page Plate.—385-*H.P. JAGUAR STATIC RADIAL AIR-COOLED AERO-ENGINE.*

ENGINEERING.

FRIDAY, DECEMBER 26, 1924.

THE METHODS OF SCIENCE.

HUXLEY maintained that the methods of science were applicable to all the problems of humanity, a contention which critics with a purely literary training interpreted as implying that nothing was of importance unless it could be weighed or measured in the laboratory. What he really meant was something very different. Socrates and Plato had promulgated the view that truth could be arrived at by purely mental processes, unchecked by observation or experiment. The Greeks, in fact, never did experiment, and were therefore quite unable to discriminate between conflicting hypotheses as to the laws of Nature. Plausible arguments could, for example, be advanced in support of the atomic theory of Democritus, but equally good *a priori* reasons could be adduced in favour of the contention of Anaxagoras that matter was continuous. Neither school could convince the other, and until Galileo introduced the principle of appealing to experiment, which was afterwards so strongly advocated by Bacon, scientific thinking could hardly be said to exist. In fact, as Henri Poincaré pointed out many years ago, there are always an infinite number of hypotheses conceivable which will co-ordinate any finite number of facts. To take a geometrical illustration, we can find equations for an infinite number of curves all of which pass through the same, say, five points. If we now require them to pass also through a sixth point, then only a certain portion of the original set of curves will satisfy this condition. In this way the fixing of a sixth point discriminates between possible and impossible hypotheses as to the nature of the curve, co-ordinating all six points. The introduction of this additional point corresponds to the making of a crucial experiment such as that by which Foucault showed that light moved faster in air than in water, or to the famous Michelson-Morley experiment which has led to such startling developments in physics. Nevertheless, to return to the geometrical illustration, there are still an infinite number of curves which will pass through all six points, and similarly so long as our observations on nature are finite in number there must always be an infinite number of conceivable hypotheses which will be in agreement with them.

In practice what we do is to choose the simplest and push them as far as they will go, rejecting from time to time any one which fails to fit in with further data as such may be acquired. It was this consistently pursued policy of comparing hypothesis with observation which Huxley had in view in claiming the general applicability of the methods of science. Science has no pretensions to establish absolute truths, but it has the negative merit of demonstrating that certain hypotheses are necessarily untrue. That heavy bodies fall more rapidly than lighter ones was a very plausible theory, but Galileo in his famous experiment at the leaning Tower of Pisa showed that in this instance plausibility was but a poor test of truth, and the adoption of the Galilean method by a few gifted individuals in successive generations has during the past three hundred years effected an astonishing revolution in the thought of mankind. Our ideas of the Cosmos have been fundamentally changed, not without vigorous protest, from the conservative instincts of mankind, but the protesters have had to keep within protesting distance and have been dragged forward in spite of themselves.

Methods of science are, however, still little applied in political and economic matters. The street corner or works gate orator still relies on the *a priori* plausibilities. Advocates of nationalisation, for instance, studiously ignore the well-established fact that no important improvement in transport has originated on a state-managed railway, and that telephony progressed much more rapidly in America than in any other country. The best hope for the future lies, we believe, in the introduction into such questions of the methods which have proved so fertile in promoting the progress of natural philosophy. It must be recognised that absolute truths are as unattainable in politics and economics as in what used to be called exact science. Consequently the real test of the relative merit of social and political conditions does not lie in comparing the results of modern civilisation with some ideal Utopia; but by observing in which countries the standard of living rules highest and freedom of thought is best secured.

Unfortunately, science can never be a popular study with more than a small percentage of the population, but it is very desirable that a knowledge of, and a confidence in, its methods should be widespread. Too often the business heads of our great industrial undertakings are lacking in this. At times they fall a prey to glib charlatans through ignoring the advice of their technical staff, whilst in other cases they buy up at high prices foreign patents for articles which could perfectly well have been developed by their own staff. We are not speaking here of the special cases in which real genius is involved, but of improvements of the humdrum type, mere matters of experiment and design, for which equally satisfactory alternatives are always possible, and which could quite well be worked out by the firm's own technical staff, to the mutual advantage both of the shareholders and themselves.

Sir Charles Parsons has stated that to keep in the forefront, an engineering firm should spend in experiment from 1 to 3 per cent. of the annual turnover. To make this procedure general it is essential that the business heads of our great undertakings shall have confidence in the methods of science. Unfortunately, educational conditions in the past have not been such as to foster this feeling. Not merely were most of our prominent schools devoted to Classics, but even that subject was very badly taught. In the October issue of the *Edinburgh Review*, for example, the late headmaster of Eton declares that classical authors were presented "to the boys as linguistic puzzles to be solved," and not as "interpreters of life." Any sort of ugly translation of the noblest passages of the great Greek writers was accepted, if fairly accurate.

Moreover, it would seem that, apart from this badly-taught subject, little else was learnt, since he states that on proceeding from these schools to Cambridge, undergraduates had to have special coaching in the simple arithmetic required for the "Little Go."

Matters have undoubtedly greatly improved of recent years, probably largely because of the steadily insistent claim of science to be considered an essential element in culture. The only hope, therefore, of maintaining the narrow classical tradition was to improve the teaching, but, in spite of this it was found impossible to continue the ban on science, though ingenious attempts were made, and with some success, to discredit the "modern side" by drafting into it all the lesser intelligences.

The teaching of classics had behind it the experience of many centuries, whilst the best methods of interesting youths in scientific studies have had to be found out by experience, and are probably not settled yet. At one time the use of text books was denounced. The teachers' lectures should, it was said, constitute the only text book, but the gift of clear exposition is, far from common, and even with lecturers of genius the policy in question is not always applicable. If current report can be relied upon, Lord Kelvin's students would have fared badly had they been dependent solely on his lectures, in which he was accustomed to discourse about things in which he might be specially interested at the time, rather than to provide a systematic course in natural philosophy.

It would, moreover, have been a very exceptional teacher who could improve on Ganot's Physics, an elementary text book, which, when school laboratories were few and badly equipped, had an irresistible attraction for the boy with scientific tastes, and gave him a very fair knowledge of a wide tract of scientific country. To-day specialisation is unfortunately more in favour, and undue importance is, possibly, attached to actual work in the laboratory. This necessitates expensive equipment, and so far as the abler youths are concerned wastes time in, say, the measurement of specific gravities which would be much better devoted to the history of scientific ideas and principles.

This question of science teaching in secondary schools was discussed in a paper recently read before the Royal Society of Arts by Professor C. A. Carus-Wilson, who stated that the difficulty was to provide for a general course in science suitable for all, in view of the fact that specialisation was demanded by the requirements of most examinations. Indeed, in this connection it may well be questioned whether the present examinations for the Whitworth Scholarships are as well designed as those of forty years ago. Fewer subjects are demanded, but a comparatively high standard in these is required, and this necessitates early, and we think highly inexpedient, specialisation. The same applies to most other science examinations. This specialisation has the additional drawback of being unsuitable for youths who do not intend to take up science as their life work. These are naturally in the majority, and it is therefore very desirable that the school science course should be such as to interest them and give some knowledge of scientific methods and principles. Professor Carus-Wilson thinks that the problem may be solved by arranging the general course in science to deal with the common objects of daily life. The idea is perhaps not new, as in the days of our grandfathers there were a number of text books, often arranged in catechism form, which were intended to afford just this kind of knowledge. The main difference is that in the plan advocated by Professor Carus-Wilson much attention is paid to experimental work, which, as the materials operated with are in common use, can be carried out relatively inexpensively. For the abler lads with natural scientific tastes this kind of experimental work may, as has been suggested above, be easily overdone. For such, much of the time often spent in making elementary measurements, might be better devoted to a widening of their scientific interests There is, however, a very large class of persons who can learn only by actual experience, and a well co-ordinated course of the type suggested will probably succeed in imparting to these a knowledge of principles which would otherwise never be acquired.

DIRECTION-FINDING WIRELESS.

A considerable work was instituted towards the end of 1920 by the Radio Research Board of the Department of Scientific and Industrial Research, under the chairmanship of Admiral Sir Henry Jackson, F.R.S., in the setting up a Committee on Directional Wireless under the chairmanship of Mr. F. E. Smith, F.R.S. This Committee has now published the first part of its main report.* Last year it produced a Special Report by Dr. R. L. Smith-Rose and Mr. R. H. Barfield, discussing the principal systems of direction-finding by reception (*vide* Engineering, September 7, 1923, page 305), and the present report begins the publication of results obtained from a network of receiving stations in this country, equipped, so far as concerns the observations of the present report, with identical apparatus on the Robinson system. These were erected, the sites chosen, and the entire work carried out, under the direction of the Directional Wireless Committee and the personal supervision of Dr. Smith-Rose. It includes the results of over 41,000 observations taken systematically at the whole of the stations in accordance with a common schedule of work, and the results are summarised and illustrated in tables and graphs referring partly to the individual stations and partly to general aspects of the entire work.

For the detail of the observations, reference must be made to the original. In everything except the design of the apparatus, and to some extent the choice of sites of the receiving stations, the phenomena investigated had to be taken exactly as they occurred, and the space involved in describing the resultant of so many complex and imperfectly known causes, though small in comparison with the labour of making and recording the observations, would be more than could usefully be devoted to the purpose. Nevertheless the net outcome of the report is important for those who are concerned with the progress of wireless transmission. The present instalment is essentially an interim contribution. It records, with the remorseless impartiality that characterises most of the Department's work, the observations that lead to a negative result no less than those that are more fruitful, and it adds little to existing knowledge except to support with its vast mass of material the negative provisional conclusions at which it has to arrive on almost all points. Among the positive conclusions is the satisfactory result that the instrumental errors of the system, including the calibration of the scale, antenna, and other non-directional effects (*e.g.*, direct pick-up of the leads from coil to amplifier through the leads and transformers of the amplifier itself), detuning the coil system, coil shape (to which reference was made in the Committee's earlier report), unscreened local oscillators, and personal operator's errors, showed the total instrumental error to be within 1 deg. and often to be under 0·5 deg., which, for the time being is thoroughly satisfactory in view of the far larger order of magnitude of the errors that may occur through less controllable influences. Much larger variations were found in some instances through unsuitable local conditions, for instance, metal work, overhead wires, trees, mountains—and though these have not yet been brought into strict relation with the effects they evidently produce, the present observations show clearly the importance of exercising the utmost possible care in selecting a site.

The hours of observation, which were uniform throughout all ten receiving stations, were for the first three months from 8 a.m. till 9.30 p.m., and afterwards from 8 a.m. till 12.30 p.m. and 4.30 p.m. till 9.40 or 10 p.m. After rejecting all inaccurate and doubtful readings, these routine observations numbered over 41,000, in addition to several thousand made during special tests. The receiving stations were at various parts of the kingdom, from Aberdeen to Bristol and Belfast, and the transmitting stations of which the bearings were observed, were at various parts both of the United Kingdom and the Continent, their distances varying from a few miles up to over 1,500 miles, and their distribution round one or other receiving station lying practically all round 360 deg. The results went to confirm the great difference in trustworthiness between day and night observations. Thus the difference between the mean observed bearing of a transmitting station from a receiving station seldom varied by day by more than 3 or 4 deg., and did not go above 15 deg.; but the night observations differed erratically among themselves by far greater amounts, ranging up to as much as 60 deg. and over, and showed differences of a similar order both from the true bearing and between night and day readings. The widest variations were, however, only of short duration, and—especially by day—the percentage of deviations that exceeded ± 2 per cent. was surprisingly low; except for one mysteriously erratic station (Bangor, which had 9·1 per cent.), the worst was under 3 per cent., counting stations that had made more than 50 observations both by day and by night. Variations were most marked and most erratic at the periods following sunrise and sunset; but though every endeavour was made to refer them to elementary causes, no really conclusive explanations were reached.

The observations described in the present part of the report were mainly on "spark" transmissions, at wave-lengths of from 2 to 9 km., but the committee's work was extended to continuous waves and relatively short wave-lengths. The results of these further observations, which are to be published in other instalments of the report, will be anticipated with the more interest because it is understood that they will show much closer approach to positive practical conclusions, and, indeed, for short wave-lengths and distances, will be able to record transmission over sea that shows a really practical concordance between true and observed bearings. When these results appear, they are likely to make out that observations on 450 metre waves up to distances of 100 miles now furnish a practical means of direction-finding, which can be used by day with so little deviation from true bearings that their readings may be taken as accurate for navigational purposes; and even by night show so little variation that as against dangers in the neighbourhood of a station ahead—which they normally would be—they give trustworthy protection in practice. Another fact of interest that is likely to emerge is that the equivalence of various systems of directional apparatus, pointed out in the Board's earlier report, has now been verified by extended sea experience, and that directional wireless is being used in navigation with satisfactory results and increasing confidence.

* Radio Research Board, Special Report No. 2. Variations of Apparent Bearings of Radio Transmitting Stations. Part I. Observations on Fixed Stations, February, 1921, to March, 1922. H.M. Stationery Office. 3s. 6d. net.

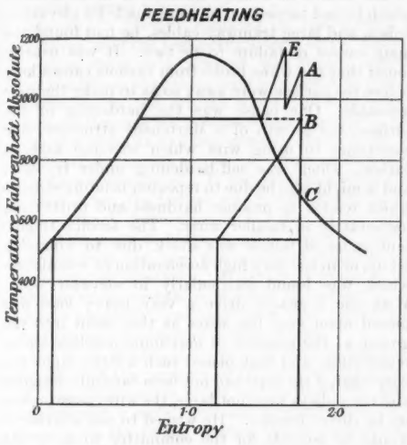
STANDARDS OF THERMAL EFFICIENCY.

A further examination of the proposed standards for determining the heat available in steam turbines working with progressive feed heating seems to indicate the probability that the suggestions outlined in Capt. Sankey's paper* will be even less acceptable to designers and contractors than we feared. In fact, the cycle represented in Fig. 1, which we reproduce below, cannot actually be realised by merely bleeding of the turbine at a sufficient number of points. Judging from the scale of absolute temperatures given, the boiler pressure in this diagram must have been about 500 lb. per sq. in. The temperature, after the steam has been superheated to the point A, is about 1,100 deg. F. absolute.

The diagram seems likely to suggest to those not fully conversant with the matter that it would be possible to obtain perfect progressive feed heating by commencing to bleed the turbine at a point where the still superheated steam was at the boiler temperature. It has, however, to be observed that at this temperature the superheated steam will have a pressure of only about 240 lb. per square inch, or less than half the boiler pressure. If passed into a feed heater none of the steam will condense unless the water in the heater is at or below the temperature corresponding to steam saturated at 240 lb. per square inch, that is to say, the feed temperature on leaving the heater cannot be higher than about

* See Engineering, December 12, 1924, page 818.

397 deg. F., whereas the boiler temperature is 468·6 deg. F. Unless condensation occurs, very little heat will be available for feed heating, as the specific heat of steam is only about one-half that of water. Hence, to get effective feed heating with steam at a pressure of 240 lb. per square inch and a temperature of 468·6 deg. F., the feed as already pointed out must leave the heater at a temperature of not more than 397 deg. F. There will thus be a large increase of entropy in the interchange of heat between the hot steam and the relatively cold water.



To realise a state of affairs corresponding to the heat represented as available in Fig. 1, it would be necessary to expand the steam right down to the saturation line. A certain proportion of it would then be transferred together with the feed at the same temperature to a compressor, and the mixture compressed adiabatically up to the boiler pressure. If the amount of steam bled off at the saturation line were properly chosen the whole would be condensed at the end of the stroke of the compressor. No arrangement of this kind appears to be yet contemplated by turbine designers, and the practical difficulties would obviously be very considerable. Hence, contractors will hardly be prepared to accept, we think, as a rational standard the method of estimating available heats represented in Fig. 1. We believe that this point of view was brought forward in Mr. Kearton's discussion of Capt. Sankey's paper.

NOTES.

Rapid Hardening Cement.

THE demands for rapid hardening cement for such purposes as making the foundations of roads, where traffic cannot be kept off the road for many days, and also in reinforced concrete construction where the work must be conducted with despatch, are so great that a large amount of attention has been devoted to the subject of late. The manufacturing companies associated in The Cement Marketing Company, Limited, of Tothill-street, Westminster, have now produced a cement which has been tested for hardening properties in the laboratories of the City and Guilds Engineering College by Professor S. M. Dixon. In this series of tests, reinforced beams 16 ft. long and 10½ in. by 6 in. in cross-section were used, made with ordinary cement and with the new product, which has been given the name Ferrocrete. The beams were carried by supports 15 ft. apart and the load was applied at two points 5 ft. apart. While the ordinary cement, specimens broke down at an average crushing load of 3,900 lb. per square inch after 54 hours' hardening; those made with new product showed an average of 14,480 lb. per square inch. Later tests after 100 hours gave 6,600 lb. per square inch for the ordinary cement and 19,145 lb. per square inch for Ferrocrete. Similar advantage in stress-resisting properties was experienced at other stages of the investigation and, in the 28-day tests, performed on Monday, December 22, the new product had twice the strength of the ordinary cement, the figures being 24,755 lb. and 12,065 lb. per square inch, respectively. Ferrocrete is stated to be a true Portland cement and though it requires a slightly longer period to harden than the well-known aluminous cement, this is regarded as not of great significance in roadmaking, where time has to be taken in laying wood blocks over the cement foundation and top dressing them with tar and grit. A section of Piccadilly, London, is now being laid with Ciment Fondu and a similar one with Ferrocrete, as a large-scale experiment of the values of these materials in road making.

The Institution of Mechanical Engineers.

Engineers, engrossed in their work, are apt to take their own proceedings as a matter of course, while the public in general certainly has little appreciation of the extent to which it is beholden to the profession for most of the necessities and refinements of life. Boyhood, with a clearer vision, usually realises that engineering and its achievements represent some of the outstanding phenomena of life, and rewards them with interest and affection, which, however, usually is all too soon lost in the light of common day. The average adult member of the public practically ignores the work of the engineer, and, in as far as he thinks about such matters at all, appears to suppose that ocean liners are produced by shipowners, great bridges by town and county councils, and express trains by railway companies. It is well that at times the public neglect should be corrected, and H.R.H. the Prince of Wales, by attending the annual dinner of the Institution of Mechanical Engineers on Thursday of last week, paid a graceful tribute to one of the major forces of modern civilisation. The dinner was the largest and most successful function of its kind which we remember, and nearly 600 members and their guests were present. The President, Mr. W. H. Patchell, who was in the chair, was particularly happy in his opening speech and in his reply to the toast of the Institution, which was proposed by the Prince of Wales. His Royal Highness, by his simile of a pack of hounds without a master, aptly brought out the value and the necessity of such an authoritative body as the Institution of Mechanical Engineers as a centre for the amazing mechanical developments of modern life. The opening speeches by the Prince and Mr. Patchell were followed up by successful contributions by Sir Henry Fowler and Sir John Aspinall, who respectively proposed "His Majesty's Ministers" and "Our Visitors," the former toast being replied to by the Marquess of Salisbury and the latter by the Earl of Derby. The toast of "Our Visitors" was also responded to by Mr. Basil Mott, who, as its president, represented the Institution of Civil Engineers. Mr. Mott's speech was the last item of a very successful evening.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of the Institution of Mechanical Engineers was held on Friday last, the 19th instant, at Storey's-gate, Westminster, the President, Mr. W. H. Patchell, in the chair.

Wire Ropes Research.

The paper taken at the meeting was entitled "Second Report of the Wire Ropes Research Committee," prepared by the reporter to the Committee, Dr. W. A. Scoble, who presented it. The report will be found abstracted in this issue on page 856 *et seq.*

Mr. Daniel Adamson, opening the discussion, said the question of lubrication shortening the life of the rope, and the fact that single wires had carried a greater number of bends when under higher tension, appeared to him to require further investigations. One million bends was the figure aimed at in the experiments. A million bends would, of course, convey different impressions to different users of ropes. Crane ropes, for instance, would last, according to circumstances, from one year up to twenty years or so—depending upon the number of lifts in the course of their work and, particularly, the load lifted. With only small loads the life of the ropes would be prolonged. Dr. Scoble had practically condemned the small pulley, and had shown in the report that pulleys of 6 in. diameter were really too small for their intended use. In the ordinary travelling crane 6-in. diameter was quite a usual proportion; 7 in. diameter was sometimes specified, while 8-in. diameter was generous. Referring to the number of bends, a large engineering firm had estimated for him the number of lifts made by their cranes as about 15,000 lifts per annum; with that a 30-ton crane rope lasted 15 years—in another crane the rope was still in use after 20 years. On a 10-ton crane the rope was replaced in 20 years. In these cases the average life of the rope was of the order of 20 years, with about 300,000 lifts in the life of the rope. That showed what one million bends meant in ordinary practice with regard to cranes.

In order to find out whether there was anything to be learnt from the experiments, he had prepared a chart showing all the results given in the report, plotting tension against bends to produce failure. The shape of the curves did show a general similarity, and he had then prepared a second chart taking only the extreme results for a given size of pulley. The region between extreme curves of this type covered in all cases a very large area. Twelve years ago he had suggested that increasing the size of the pulley by two rope circumferences would double the life of the rope. The rule was empirical and left much to be proved, but the present work confirmed the suggestion. On his second chart he had shown curves drawn to the form of hyperbolas using various constants. The range he had worked on was from 1,000 lbs. to 200 lb. tension and the constants used in his formula $x \times z = \text{constant}$, were as follows:—

Size of Pulley.	Constant.
6 in.	50×10^6
8 in.	100×10^6
10 in.	200×10^6
12 in.	400×10^6
14 in.	800×10^6

The 6 in. curve accorded very closely with the actual results obtained. The 8-in. curve was rather below the lowest test results obtained from the 10-in. pulley; the 10-in. curve was between the upper and the lower limits of the 10-in. pulley. Similarly the 12-in. and 14-in. curves also fell well into the region indicated by the experiments. For the present he thought such a chart was a reasonable guide for designers, and bore out the suggestion made years ago that the life of the rope under similar conditions would be doubled if the diameter of the pulley were increased by two rope circumferences.

When, in 1912, he had read a paper on "Wire Ropes" at Belfast, Mr. A. B. Wilson mentioned that, in the College of Technology, in which the meeting was held, a change had been made in the arrangement of the passenger lift. From the old arrangement with three primary bends and two reverse bends, a change had been made which introduced only one primary bend. He had made a wild guess twelve years ago that the new rope ought to last seven times as long as the old. With the old arrangement the ropes lasted about a year and three-quarters, allowing for holidays; with the new they lasted eight years—roughly four times as long—but in the latter case the lift was making more trips per week and working at higher speed. Allowing for difference of lifts per week, and allowing something for acceleration at the higher speeds, his wild guess of 7 to 1 did not appear to be very far out. With regard to partial bends, recent experiences at the Eiffel Tower had shown that a partial bend of 20 deg. or more, was as bad as 180 deg. The Department of Mines, after an accident at Nuneaton with haulage ropes, recommended that haulage ropes should have a maximum life of eighteen months. If the Committee's work showed that by making modifications, the life of the ropes could be doubled, it would mean a considerable saving to the collieries. Further tests were needed on larger ropes, with higher tensile strengths—120 tons instead of 80 tons. Reverse and partial bends should be dealt with. The vital question for determination was, how long should a rope last, and by how much could the life of the rope be prolonged by making various improvements in the arrangements.

Mr. Robert Armitage remarked that he was connected with one of the largest colliery concerns in the country and had to buy large quantities of ropes, and was also connected with a steel works. He

desired to bring forward two points, firstly, the grade of wire. He believed that the only way to get sound wire was to begin with a sound ingot by casting with the big end up and a feeder head. In the bulk of the cases in this country there was no direct connection between the rope maker and the steel maker. In many instances the steel maker had been at fault. To illustrate his point he showed two slides. One of these represented sulphur prints of parts of a rope that broke. In several places there were black sulphur spots in the centre of the strands. One of these strands, taken out and ground half way through, when sulphur printed showed a series of cups all along the wire. That had arisen from the presence of a pipe down the ingot. As the wire was drawn the pipe containing segregates did not flow as easily as the outside, and so a wire was produced which was known as "cupped wire." He believed that a great deal of wire went into ropes which was cupped in the manner he had shown. His second slide illustrated a steel-making fault of another kind. When a lot of steel had to be poured from a ladle, the first few ingots were often teemed very fast and the teemed ingots were far too hot. The slide showing a print of a section of a cable depicted the chilling on the outside of several strands. The quality of steel indicated ought never to have got into a rope at all. The wire had been made from steel cast far too hot.

Some of the faults arising in ropes were a consequence of the fact that the wire had been put into the rope in a very highly overstressed condition. When the strand broke it did so with a broken edge. On turning round the pulley the edge cut into the neighbouring strand, and the effect of such nicking was similar to that produced in the Izod test. That probably pointed to the fact that with lower tensile strength the wires would make a better rope. The steel would be in a much better condition if it were not so highly stressed on the surface. While salesmen might like to run up the tensile strength of their wire ropes, users, he thought, rather wanted wires less overstressed.

Mr. C. H. Woodfield said that on several occasions he had put ropes on cranes, which had lasted only a fortnight. That was in striking contrast to certain instances given to the meeting. The ropes were returned to the maker, and other ropes from the same coil were supplied, but failed in a similar way. Finally another rope was provided, apparently from a different coil, and proved quite satisfactory. In practice everyone lubricated ropes, and he had been very astonished by the results in the report. Unless the rope were lubricated there would be some sort of action which would be detrimental to the life of the rope. Mr. Woodfield next referred to a luffing crane at a warehouse, in which he had modified the leads of the ropes with good effect. To accomplish this he had put all the gears at the top of the building. Compared with the old conditions under which the ropes lasted about three to five weeks, the life was now about seven to eight months; these cranes, it should be remembered, were working every minute of the day every day of the week, and were doing about 400 lifts a day. The new arrangement had saved two out of four bends, thus halving the number. The slewing of the cranes had been done formerly by chains, but he had, in the particular case he was considering, used ropes for this. Those particular ropes had lasted from 12 to 18 months. He considered that the arrangement had been a great success. In another crane arrangement he had abolished the derrick ropes, the luffing of the jib being accomplished by guys attached to a cross-head worked by screw-down inclined guides. Luffing ropes were often badly neglected. In practice ropes were not allowed to break, but they stretched and were reduced in diameter. The life of a rope was determined when warning was given by the strands breaking.

Mr. C. H. Wingfield wished to call attention to the curious effect of single wires in the repeated bending tests, lasting better with a high tension. He remembered that a coppersmith had told him that when utilising copper pipes between bulkheads without proper expansion joints, the pipes became too long and had to be cut out and joined up again; whereas when wrought-iron pipes were used, the reverse happened. The latter shortened and had to be cut and have pieces put in. If they considered a short length of wire, if this were bent within the elastic limit the neutral axis would be central; if stressed beyond the elastic limit the neutral axis would move to one side. The effect of the tension and compression would then be unequal on the two sides. When moved back, the neutral axis again moved and this action he thought might produce shortening. The idea was vague, but might possibly point the way to further investigation. Experimenting with copper and steel wire would be of interest to find out whether the action was different. He congratulated Mr. Adamson on the success of his theory, which he (Mr. Wingfield) had believed in from the first and which agreed with the facts as far as ascertained. Referring to the hardening of wire by repeated bending, if a copper wire were used, it ought not to be strained too much. Bellhangers had found that copper wire was of no use at all for hanging bells until it had been, as they termed it, "killed." If a 20-gauge copper wire were pulled, it would give way quite easily, but suddenly stopped. It was then "killed," and after that it would remain the same length. There again was the hardening effect.

Mr. G. Stevenson Taylor, continuing the discussion, asked first whether the hemp cores were lubricated in the usual way before the rope was made up? Further, at what rate was the bending carried out? He thought it would be useful if information on that could be supplied. Although the committee had not been able to come to any definite conclusion with regard to the life of a rope, so as to enable users to decide definitely when a rope should be scrapped, he thought that up to a certain point the breakage in most cases took place first comparatively slowly, followed by a sudden jump. The point at which the jump took place was, he thought, important and should afford some guidance in the matter of the life of the rope. Unfortunately, a very large number of accidents occurred every year in this country through the breakage of wire ropes. There was no doubt that a large number of these would be avoided by proper examination. Ropes should be examined regularly from the time they were put into use, but as soon as any breakage of wire occurred the frequency of the examinations should be considerably increased. The statement was made in the report: "The fractions of the breaking tensions in these cables, 1 to 4, necessary to cause failure after one million bends on the 14-in. pulley were, approximately, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{10}$ and $\frac{1}{8}$ respectively, yet this pulley had a diameter three times that which was calculated to give yield point stress in a wire bent round it, so that tests on still larger pulleys appear to be desirable." He quite agreed with that, but he also thought the results tended to show that in a large number of cases wire ropes were being used over pulleys at much too high a tension. He knew it was qualified by the statement "after one million bends," but the pulley was a 14-in. one equivalent to about 45 diameters of rope, whereas under normal conditions the pulley ratio rarely exceeded about 20. So that if a breakage occurred with, in some cases, only one-tenth of the breaking tension, he thought the question of the safe tension for the ropes required to be very carefully considered.

Mr. H. D. Lloyd said that on the subject of wire ropes it was a curious fact that, while there was plenty of practice, there was practically no precept to guide them. The question of increased bends at greater stress was a very curious one. He did not know whether it had been suggested that it had anything to do with the fact that the elastic limit in compression of wire was less than in tension. In patent steel, such as was used in the experiments, the elastic limit would, he thought, be somewhere of the nature of about 55 tons or 65 tons to the square inch in tension. In compression, as far as it is possible to judge—it was very difficult to ascertain exactly—it would be perhaps only two-thirds of that amount. That might have something to do with the point, and it was a curious fact that in testing wire for bend, if the wire was perfectly straight it would give a greater bend test, while if it had an initial curve or wave in it, it would give a lesser bend test. With a greater tension on the end of a wire rope running over a pulley one would expect that the wire would be straightened out and would in effect give slightly higher bending values. He regretted that in many cases in the report a direct comparison was impossible for different cables with the same diameter of pulley and the same load.

The method of application of the loads in the testing apparatus described did not appear to reproduce in any way the stresses due to heavy acceleration and retardation which so often occurred in practice, as in hoists, elevators and similar work. In the course of a large number of investigations which he had carried out on ropes made for elevators, hoists, and large tramway cables, he had found the main causes of failure to be two. It was usually found that the wires broke from various causes long before the surface wore away so as to make the rope unusable. One cause was the hardening of the surface, the growth of a Martensite structure, due sometimes to using wire which was too high in carbon, which was self-hardening under friction; and it might also be due to repeated bending stresses which tended to produce hardness and brittleness, particularly in smaller wires. The second important cause of failure was shock due to vibration set up, or to the very high acceleration or retardation which was found particularly in elevator work. With the V-groove drive a very heavy load was placed upon very few wires as they went into the groove at the moment of maximum acceleration or retardation, and that placed such a stress upon the wires that, if the rope had not been carefully designed and the pulleys were not large, the wires were broken up by direct tension. He wished to ask whether it would be possible for the committee to carry out experiments with ropes of larger diameters, with suitable-sized pulleys. Certain other constructions, such as the 6:19 three-size wire construction, as it was called, which was now almost standardised in the United States, should be tried. In that construction the wires were all made up with the same length of lay, and they had line contact throughout instead of point of contact where different lays crossed each other. It possessed the theoretical disadvantage that it did not preserve the same angle of lay in each strand, but in practice it had so many advantages (there was no nicking of the strands of wire under pressure and so on) that it was becoming very much of a standard in other countries, and he thought it should do in this country also.

Mr. Atkins said it was unfortunate that the results were so indefinite, but it was very easy to see why that was so. The number of factors that had to be borne in mind in connection with the life of a rope was very large indeed. The quality of the steel was fundamental. This it was necessary to examine from every other point of view. The next point that had to be considered was the kind of patenting or tempering. The quality of the tempering if good steel was obtained was the most important factor of all. A third point was the method of wire drawing and the treatment of the rod or wire in the process. Before making up into a rope full physical tests should be made of the wire. It would have been far better in the cases investigated if full physical tests had been made of the wire. The report stated that the elongation was 1·6 per cent. of the fracture. He did not know what that meant. An important factor in the life of the rope also was whether the strands and the rope had been spun up slackly or tightly. Finally, and perhaps most important of all, it was necessary to consider the treatment rope received in service.

Occasionally a bad rope was met with and no apparent reason could be given for its failure. After examination in every possible way, the only conclusion sometimes possible was that the rope had been given a very great snatch. He thought really that it would have been far better to test the ropes with a dead load instead of with springs. It came as a surprise to him to find that ropes lasted longer without lubrication. If that occurred with the rope with a hemp core it might have been due to the fact that the hemp was well greased and supplied the lubrication. If it referred to the rope with the solid core, all he could say was that it was probable that the wires were soap-drawn. Wires were drawn usually with the very best olive oil soap, and they would

carry away a thin film of a solid lubricant and possibly that actually proved better than the oil used. He had often come across ropes that had been broken through friction. In these cases the ropes had been rubbed so much that the heat generated by the friction had converted the surface of the wire which had been rubbed into a Martensite condition. In support of that he showed a microphotograph of a part of one wire taken at a magnification of 100 diameters and illustrating an instance in which the rubbing surface had been converted into a layer of hard Martensite. That commonly happened in high-carbon wire run without proper lubrication.

Mr. E. C. Stevens, speaking on the subject of lift drives, said the best position for a drive, whether it was a drum or a V-wheel, was always directly over the lift, so that there need be no guiding pulleys in addition to the driving wheel. If the V-drive wheel, in the case Mr. Adamson had referred to, had been put right at the top, directly over the lift, he suggested the results would have been equally good as with a drum drive. It had been suggested that in that drive, the tension was rather greater in the case of the V-drive than in the case of the drum drive. It must be borne in mind, however, that in a drum drive the rope was anchored securely, and there was no elasticity. With the V-drive it was possible under certain conditions of loading to get a slight elasticity, and very often that was of help in softening the shock of a fierce brake.

Dr. W. A. Scoble, in reply, said that undoubtedly the effect of the pressure of the wire on the pulley, *i.e.*, the compressive stress on the wire, no doubt coupled with a certain amount of relative motion of the wire on the pulley altering the structure of the rope, was of very great importance. Sufficient attention had not been paid to this. With regard to the question of lubrication, he had come across lately a case in which the cables working through fair-leads, and not over pulleys, were now not lubricated, because in service it had been found they lasted considerably longer working unlubricated than lubricated. Thus, in certain practices it had been definitely established that the cables were used without lubrication. He was referring to aeroplane control cables. One difficulty was that if they were used in sandy districts particularly, the lubrication was liable to take up sand, and action was set up which was very severe upon the ropes.

A vote of thanks was then passed to Dr. Scoble for the great time and trouble he had taken in acting as the Reporter of the Committee.

Finally, the President announced that there would be an informal meeting on Friday, January 9 next, when the subject of discussion would be the Maintenance of High Compression Oil Engines. On Friday, January 16 next, an informal meeting would be held, at which the subject would be Transportation in Engineering Works. The next ordinary general meeting would take place on Friday, January 23, when two reports of the Cutting Tools Research Committee would be presented.

LABOUR NOTES.

THE members of the Electrical Trade Union in the London area are not, of course, alone in believing that non-unionists and men in arrears with their society contributions should not be allowed to work. Many other organisations of skilled operatives are of much the same mind, although in seeking to give effect to their views they are, as a rule, more discreet. When the electrical workers at the Kensington and Brompton station demanded the discharge of two fellow-employees who were in arrears with their dues the management is reported to have retorted that it was no part of an employer's duty to act as debt collector for the union. On its face that is a perfectly reasonable attitude for an employer or his representative to take up, and organised labour stands in its own light when it puts forward arguments to the contrary backed by threats of a strike. The fact that men have allowed their membership of their union to lapse is not a thing that an employer can properly be blamed for. If blame attaches to anybody or anything, apart from the men themselves, the fault is to be looked for in the union itself, which has clearly lost its attraction for, at any rate, the men who have lapsed. The convenience of the general public is not usually a consideration with extremists, but the electrical workers, the engineers, the miners, and one or two other crafts are exceptionally dull if they do not perceive that strikes or threats of strikes against non-unionists are regarded by the community as not only wasteful, but foolish. The man in the street quite frankly agrees that whether a trade is wholly or partially organised is not a matter which need concern an employer.

The preliminary report, which the delegation sent to Russia by the Trades Union Congress, have issued contains very little that can be described as unexpected. Mr. Purcell and his fellow-tourists were much impressed by what they saw of Russia's progress under the rule of the Union of Socialist Soviet Republics, and promise to give in the full report which they are preparing for submission to the General Council information which will justify the Trade Union and Labour policy of supporting the full diplomatic and economic recognition of Russia. Until that information is available it would serve no useful purpose to offer any observations, from a trade union point of view, on the results of the visit. Presumably, the report will contain something about the alleged agreement between the deputation and representatives of Russian Labour jointly to promote world trade-union unity over the heads, as it were, of the International Federation of Trade Unions. What the General Council will do about this is not easy to foretell, but, in view of the meeting of the I.F.T.U. in February, at which the question of unity is to be discussed, it will clearly have to do something decisive if the international movement is not to be hopelessly divided.

The average worker in this country will also, we imagine, like to hear more about the ways and means which are being taken by the Soviet authorities to increase production. For instance, piece-work is, according to official information, being extensively introduced. What are the conditions under which it is being operated? Is there a machine question in Russian engineering? If there is, what is the Soviet solution of it? Are there rigid lines of demarcation between trades? Is overtime absolutely barred? On several other points the average worker in this country will be glad, we believe, to get information; and, no doubt, the delegation has remembered them.

The controversy which has arisen at Glasgow over the labour conditions to be observed in the construction of Lord Weir's "steel houses" was not unexpected. The idea to which Lord Weir's firm is giving expression is, broadly, to produce the parts of certain standard types of houses by repetition processes in the shops and assemble them on the site. Naturally, that arrangement cuts across the practice of the various crafts belonging to the building trades, although, obviously, it is a way to make up the shortage of houses quickly and cheaply. According to Mr. R. Coppock, the Secretary of the National Federation of Building Trade Operatives, the building trades are not, by their action in this instance, trying to prevent the erection of any alternative type of house. All that they demand is that the conditions agreed in the industry between the building employers and operatives with regard to wages and conditions shall be given effect to on all alternative methods of building following building trade practices. On its face, that is a demand to which the community may not unreasonably take exception; but, in all the circumstances, it will be wise, perhaps, before drawing definite conclusions, to wait until Lord Weir's promised estimates of the costs of producing in mass are available.

IN a recent speech Mr. F. G. Dzerzhinsky, the chairman of the Soviet's Supreme Economic Council, was much more explicit about the "improvement" in Russian production than Mr. Purcell and his associates have permitted themselves to be. In comparison with pre-war, he said, the output of large-scale industry had reached an average of 46 per cent., oil 65 per cent., coal 50 per cent., flax 72 per cent., wool 89 per cent., leather 49 per cent., heavy chemicals 59 per cent., rubber 68 per cent., sawn timber and three-ply 54 per cent., and paper 47 per cent. It was anticipated that during 1924–25 there would be a further average rise in the industrial output of about 30 per cent. to 35 per cent. There were, however, Mr. Dzerzhinsky proceeded to point out, limits to the extension of industrial output. The realities of the situation and the financial position must be taken into account. The metals industry desired to extend its programme of output, without having the means to pay wages regularly, but the amount of credit the State could advance was limited, and the programmes of output of the various industries should only be drawn up in accordance with a properly thought-out plan for the whole of industry throughout the Union.

The Supreme Economic Council had, the speaker went on to say, improved its work considerably in this direction. Nearly all the plans of output for 1924–25 had already been drawn up and examined by the departments responsible, whereas last year the fuel plan, for example, had not been ratified before July, and the plan for the metals industry only in May. The Council would endeavour to help in every way by giving credits and subsidies, for not only was the metals industry in a very difficult position, but its successful expansion would help considerably all the numerous industries dependent on it. Nevertheless, Mr. Dzerzhinsky said, in the interests of sound finance the original programme of output had been reduced from 303 million poods to 273 million poods, the proposed subsidy to the industry being reduced from 47 million roubles to 36 million roubles, and the grant of additional credits from between 89 and 90 million roubles to only 75 million roubles. It was particularly satisfactory to note that year by year the subsidy to industry was decreasing, bank credits taking their place. The direct profits to the State, on the other hand, were increasing. In 1922–23 these profits amounted to 4,415,000 roubles, and in 1923–24 to 45,000,000 roubles. They were estimated to reach 59,000,000 roubles in 1924–25.

During the second quarter of the past economic year there had been, Mr. Dzerzhinsky said, a general rise in the cost of production; but in the third quarter, side by side with a reduction of prices, there had been a reduction, although not to the same extent as the decrease in prices. Comparing the number of workers employed, the fuel consumed and the output with the pre-war figures, he stressed the fact that the output ought by now to be far greater than it is and the cost of production much lower. The problem which that represented was, however, it was added, engaging the attention not only of the central authorities but also of all the economic departments and industrial boards.

According to "The Chinese Economic Bulletin," which is compiled and published by the Chinese Government Bureau of Economic Information, the Shansi authorities are teaching their soldiers different kinds of industrial pursuits so as to make them useful members of the community after their return to civilian life. The gun-making department of the Soldier Apprentice Corps is reported to be turning out excellent Service rifles, a bonus of 8 dollars being paid for each rifle manufactured. An electric plant was recently installed in the Training Factory—another branch of the new organisation—to supply power and light to the public at a lower rate than that of the city electric company. The plant is manned entirely by soldiers.

The Monthly Trade Report of the United Patternmakers Association states that although a rather larger number of branches are showing trade to be good, the number of members registered as unemployed at the end of October was only 15 less than at the end of September.

Mr. Lorimer, the general secretary of the Associated Blacksmiths' and Ironworkers Society, states in his report for the third quarter of the current year that the number of members signing the Unemployed Register at the end of September was 1,744—equal to 14 per cent. of the membership. That represents an improvement on the June figures, but is still treble the pre-war percentage. The most definite change for the better has been, he says, in the shipbuilding and ship-repairing industries. In marine engineering the prospects are brighter, but work is apparently being held up until after the holidays. In the wagon-building and locomotive industries, trade is fair in some centres and at a complete standstill in others, while members employed in the steel industry are experiencing the most acute depression in the history of the trade. In some areas almost the whole of the members of the Society are unemployed. The membership of the organisation is now 12,205.

The members of the Amalgamated Society of Woodworkers have by a substantial majority adopted a proposal to appoint a full-time executive council. It has also been resolved, but by a much smaller majority, to move the general offices of the organisation from Manchester to London.

The National Wages Board, to which the question of the mileage basis for enginemen was referred by the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen and the Railway Companies has decided that "in all the circumstances it would not be desirable to make any alteration" in the system "at present in operation." As the contention of the workers' representatives was that the basis should not be increased from 140 miles per day to 150 miles per day, there is no reason to suppose that the report of the Board will be unacceptable to them.

THE SISKIN II AEROPLANE AND JAGUAR AERO ENGINE.

The single-seater fighting aeroplane played such an important part in the conduct of the late war, both in warding off hostile aircraft and in attacking entrenched troops, that the development of the type must be carefully fostered in any system of aerial defence. The most desirable qualities in the single-seater fighter are high speed, good climbing power and sufficient control to give good manœuvrability, the latter, of course, involving heavy strains on the structural members and thus necessitating the use of a high factor of safety. As an example of a machine designed to fulfil these somewhat onerous conditions, we illustrate in Figs. 1 and 2, on page 864, the Siskin II single-seater fighter, constructed by Sir W. G. Armstrong, Whitworth Aircraft, Limited, of Coventry, and fitted with a 385–425-h.p. Jaguar engine, built by Armstrong-Siddeley Motors, Limited, also of Coventry.

The Siskin II represents a type of aeroplane originally designed for and supplied to the British Government, and embodying the experience gained with fighting machines during the war, as well as that derived under peace conditions subsequently. As will be seen from the illustrations, it is a single-engined tractor biplane with a positive stagger to the wings, and a good dihedral angle. The latter, it may be mentioned, amounts to 3½ deg., and the stagger is 21·4 in. The upper wing has a span of 28 ft. 4 in., with a 6-ft. chord, while the corresponding dimensions of the lower wing are 22 ft. 3 in. span and 5-ft. chord. This gives a total wing area of 253 sq. ft., and since the weight of the machine, fully loaded, is 2,250 lb., the wing loading works out to 8·9 lb. per sq. ft., and the horse-power loading to 6·5 lb. The other main dimensions of the machine are:—Length overall, 21 ft. 6 in.; height, 9 ft. 6 in.; and gap, 4 ft. 4 in. The useful load carried is 400 lb., including the pilot, but exclusive of fuel and oil.

The wing structure calls for no particular comment, the spars being of spruce, of hollow section, and the interplane struts of steel. It is important to notice from the illustration, however, that a complete system of bracing is provided for the lower plane, so that if one of the wing struts is shot away in flight, the machine is not put out of action. In general, the bracing is arranged so that if any wire is broken, its load is distributed between two others, and the whole structure is designed for a factor of safety of six above the normal loading in steady flight. The fuselage is of steel tubular construction with steel tie-rod bracing on a patented system, in which no welding is employed. The pilot's position is such that his eyes are in line with the chord of the upper wing, so that he can see either over or below it, part of the wing being cut away for the purpose, as shown in Fig. 2. The lower wing, having a shorter chord than the upper one, offers but little obstruction to the view downwards, and, since the fuselage is comparatively narrow, the pilot can easily see over on either side, as is necessary in landing. The landing gear, which is well shown in Fig. 1, is of the Oleo type, and this, in conjunction with the comparatively low landing speed of less than 50 miles per hour, enables the machine to alight safely in small fields or on rough ground. A tail skid, swivelling with the rudder, is provided to facilitate the steering of the machine when taxying on the ground. The controls are of the usual type, and the form of all the control surfaces is shown in Fig. 2, from which it will be seen that only the rudder is balanced. The tail plane, however, can be adjusted in flight, and the machine is inherently stable when trimmed to fly at its normal speed. It can thus be flown in this condition without the use of the control column, so that the pilot is free to attend to the gunnery. Two rifle-calibre guns can be carried directly over the steel longerons of the fuselage, which are of ample strength to withstand the effects of the recoil. With this arrangement of the armament, the ammunition box, which holds about 2,000 rounds, is fixed across the fuselage between the two guns. An additional gun can be carried on the upper wing if required.

As previously mentioned, the machine is fitted with the Armstrong-Siddeley Jaguar engine, and was, in fact, specially designed to employ that engine. The engine itself we shall describe below, but we may now mention that it is mounted on a steel frame in front of the fuselage in such a manner that it can be removed complete without disturbing the accessories. The cowling, as shown in Fig. 1, is of a simple character, and is arranged so that it remains attached to the engine when the latter is dismounted. All the ordinary engine adjustments can be carried out with the cowling in position, a large door being provided on each side of the machine to give access to the carburettor, magneto, &c. Petrol is fed to the carburettor from a gravity tank mounted on the top of the fuselage and holding 12 gallons, which is sufficient to run the engine for about 45 minutes. The main supply of petrol is carried in a 28-gallon tank mounted inside the fuselage, the fuel being pumped up to the gravity tank by means of a wind-driven pump. Any surplus petrol drains back from the gravity tank to the main tank, passing through a sight glass provided to enable the pilot to assure himself that the pump is working properly. To minimise the risk of fire, a fire-proof bulkhead is located in the fuselage between the engine and the petrol tank, and the air intakes of the carburettor are carried well away from the machine. A tank holding 5 gallons of lubricating oil is mounted on the lower surface of the upper wing as shown in Fig. 1.

In the fully-loaded condition, when the weight of the machine, as previously mentioned, is 2,250 lb., the maximum speed near the ground is 148 m.p.h., the speed falling off to 140 m.p.h. at an altitude of 10,000 ft. and to 130 m.p.h. at 22,000 ft., when fitted with a Series III type Jaguar engine, rated at 360 B.H.P. The last-mentioned altitude is reached in 25 minutes, but the machine can climb to 10,000 ft. in 8 minutes; its ceiling, with full load, is 26,000 ft.

As previously stated, the Siskin aeroplane was specially designed to employ the Armstrong-Siddeley Jaguar engine, and this we illustrate on Plate LXXXIII which accompanies this issue, and also on page 871. Figs. 3 and 4, which are, respectively, three-quarter front and rear views of the engine, show its appearance very clearly, while its general arrangement is illustrated by the transverse and longitudinal sections reproduced in Figs. 5 and 6. Various details, which will be referred to later, are illustrated in Figs. 7 to 11 on Plate LXXXIII and in Figs. 12 to 16 on page 871, while the results of bench trials are plotted in Fig. 17 on the same page. As will be understood on reference to the illustrations, the engine is of the static-radial, air-cooled type, having 14 cylinders arranged in two planes around a central crankcase. The seven cylinders of each group have their pistons connected to one of the crankpins of a two-throw crankshaft, on the forward end of which the propeller is mounted without any reduction gearing. The carburettor, magnetos and distributors are located at the rear of the crank-case, as shown in Figs. 4 and 6, which also show the pressed-steel flanged ring provided for bolting the engine to the mounting. Although nominally rated at 385 h.p., the engine develops 435 brake horse-power at maximum speed and gives 405 brake horse-power at its normal speed of 1,700 r.p.m. Under test conditions, as shown in Fig. 17, the power developed at the speed mentioned was about 408 h.p., while the maximum reached was about 445 h.p. The engine, in the dry condition, weighs 780 lb. (± 10 lb.), the mean figure giving a weight of about 2 lb. per horse-power at the normal output.

The design of the cylinders is interesting and is shown in the sections Figs. 5 and 6, while the head is illustrated to a larger scale in Figs. 10 and 11. The head, it will be seen, is of approximately hemispherical form and is cast of an aluminium alloy, the barrel, which is turned from a steel forging, being screwed into the head and secured by a locking ring. For attaching the cylinders to the crank-case, steel adaptor sleeves are screwed onto the lower ends of the barrels, the sleeves being formed with flanges which fit into corresponding recesses inside the crank-case casting, and being held in position by means of screwed locking rings outside the crank-case. A careful examination of Figs. 5 and 6 will make the arrangement clear. The cylinders are 5 in. in diameter internally and the piston stroke is 5½ in.

The design of the pistons, which are of cast aluminium alloy, is best shown in Figs. 7 and 8, from which it will be seen that there are three rings in the land below the domed head, two of the number being gas rings and the other an oil-scraper ring. A second scraper ring is provided near the lower edge of the skirt. The gudgeon pins, which are hollow, float in both the pistons and the connecting rods, lateral movement being prevented by split rings. To connect each group of pistons to the crankshaft, one master-rod of H-section and six tubular auxiliary rods are employed, the arrangement being clearly illustrated in Figs. 5 to 8. The big end is of steel made in two parts and lined internally with white metal to form a bearing for the crankpin. The hollow wrist pins for the auxiliary rods are of the floating type, working in phosphor-bronze bushes housed in the cheeks of the big end, as shown at the bottom of Fig. 7. The master-rod is rigidly secured to the big end by two pins fitted one above the other, and fitting into plain holes in the cheeks of the big end, as will be clear from Fig. 7.

The crankshaft, best shown in Fig. 6, is made in one piece with two throws 180 deg. apart, balance weights of gun-metal being bolted on to extensions of the webs, as will be clear from the illustration. The shaft, webs and crank-pins are drilled and plugged as shown, in connection with the lubrication system, which will be referred to later. Plain roller bearings are fitted close to the throws, while a combined ball thrust and roller bearing is fitted at the forward end just behind the air-screw boss. The thrust bearing, it should be mentioned, is designed to take thrust in either direction. Details of the timing gear, which is located between the throws and the thrust bearing, are shown in Figs. 5 and 6, but the gearing is more clearly illustrated in Fig. 9. Two cam rings are provided, one for the inlet and the other for the exhaust valves, the rings being bolted together and mounted on a ball bearing fitted on to the crank-shaft. A toothed sleeve keyed on to the latter engages with a pair of intermediate spur gears which run in roller bearings carried by a stationary frame. Pinions on the inner ends of the intermediate gear shafts engage with an internal gear bolted on to the cam ring, driving the latter at one-sixth the speed of the crank-shaft and in the opposite direction of rotation.

One inlet and one exhaust valve, of the overhead type, are provided for each cylinder, the valves being seated on aluminium-bronze rings forced into position as shown in Fig. 10. The valves are worked by rocking levers and hollow push rods, the latter being operated by tappets carrying rollers which engage with the cam rings. Figs. 5 and 6 show the arrangement of the push rods and tappets most clearly, while the design of the tappets is best shown in Fig. 9. The construction of the valves and rocking levers, which are mounted on ball bearings, can be followed by examining Figs. 10 and 11, the latter also showing the faced connections on the cylinder head for the inlet and exhaust pipes. The latter are short steel bends cut off at about 45 deg. and slightly flattened at the ends as shown in the half-tone engravings, Figs. 3 and 4, as well as in the sectional illustrations, Figs. 5 and 6. The induction system of the engine is particularly interesting, its special feature being the employment of a fan to draw the mixture from the carburettor and to supply it uniformly and at a pressure above that of the atmosphere, to the pockets covering the inlet valves on the cylinder heads.

The general arrangement of the system is best shown in Fig. 6, from which it will be seen that the fan is located at the rear of the engine and is driven directly from the crankshaft. The fan inlet is connected to the carburettor through a heater box, around which hot lubricating oil is circulated as will be explained later. The hot oil is also passed through a chamber formed in the fan casing as shown in the figure. This arrangement, of course, has the dual advantage of cooling the oil and warming the mixture, while the fan action ensures a thorough admixture of the air and petrol vapour. A longitudinal section of the fan is reproduced to a larger scale in Fig. 12, on page 871 and from Fig. 13, which represents a front elevation of the casing, it will be seen that seven induction pipes are connected to the periphery of the fan casing by packed expansion joints. Each pipe is divided into two by a breeches piece near the joint, and connections are made by means of elbows to each of the inlet valve pockets on the cylinder heads. The connections are clearly shown in Fig. 4 on Plate LXXXIII and also at the bottom of Fig. 6.

An extension of the fan shaft carries a bevel wheel from which the drives for the two B.T.H., 14-cylinder magnetos, are taken, and the drive for the tachometer is obtained from a screw gear at the extreme end of the shaft, as shown in Fig. 13. The carburettor, which can be seen in Figs. 4 and 6, is a Zenith dual type 55 D.C., and, as previously mentioned, a box jacketted with hot lubricating oil is fitted between it and the inlet to the fan. The engine is lubricated on the dry-sump system and the oil pumps, which are of the gear type with vertical shafts, are mounted in front of the crankcase as shown in section in Fig. 5, so that they are readily accessible. Of the two pumps there indicated, the upper one, which is the pressure pump, delivers oil from the supply tank through a strainer to a sleeve surrounding the crankshaft. The oil passes through a hole in the crankshaft into an axial passage in the latter and flows through holes in the webs to both the crankpins. Holes in the latter enable the oil to pass out into recesses formed in the big-end bearings, which are thus lubricated, and also cooled, since the oil supplied is greatly in excess of that necessary for lubrication alone. The oil which escapes from the bearings lubricates the cylinder walls, gudgeon pins and other moving parts on the splash system, eventually collecting in the crankcase; but the greater part of the oil returns from the recesses in the big-end bearings, flows through a second passage in the crankshaft and leaves mainly through a hole at the forward end near that through which it entered. Some of it, however, passes out through a lateral hole in the crankshaft near the bearing for the timing gear. The latter is thus thoroughly lubricated and the oil, which is circulated through the crankshaft as described, serves to carry off the heat generated by bearing friction in a most effective manner. The

DETAILS OF 385-H.P. JAGUAR AERO ENGINE.

CONSTRUCTED BY MESSRS. ARMSTRONG SIDDELEY MOTORS, LIMITED, ENGINEERS, COVENTRY.

Fig. 12.

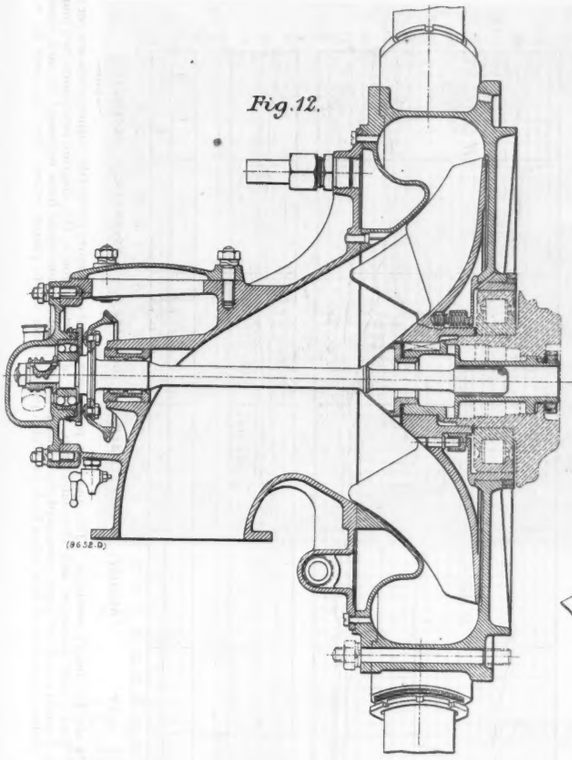
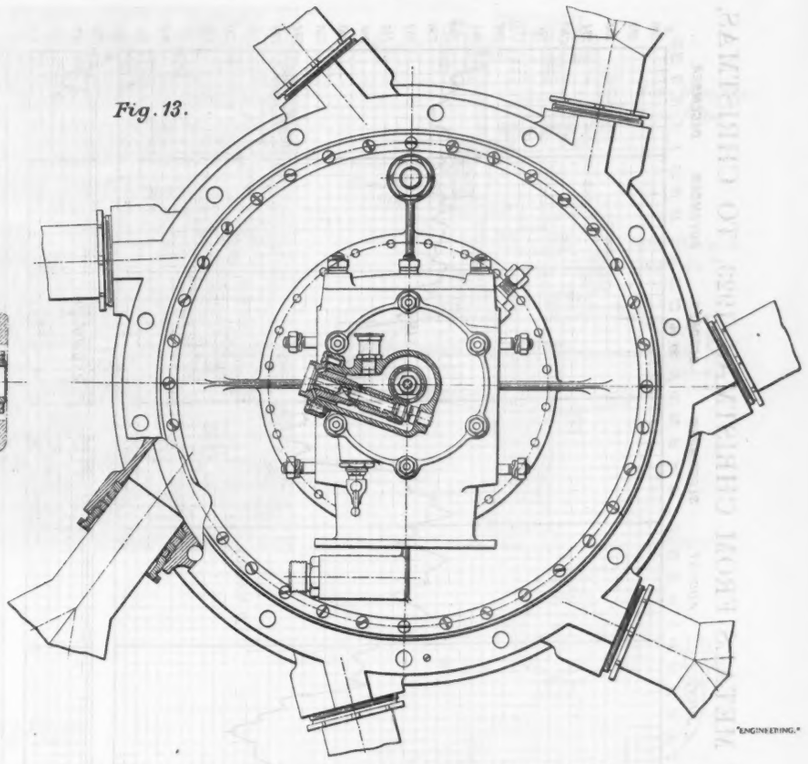


Fig. 13.



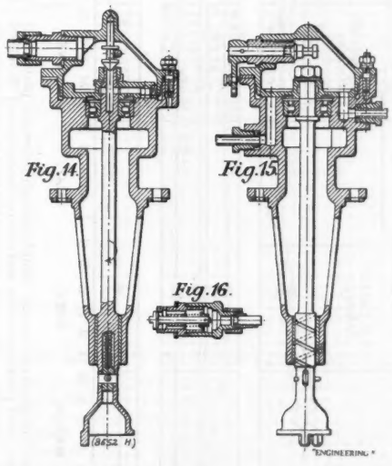
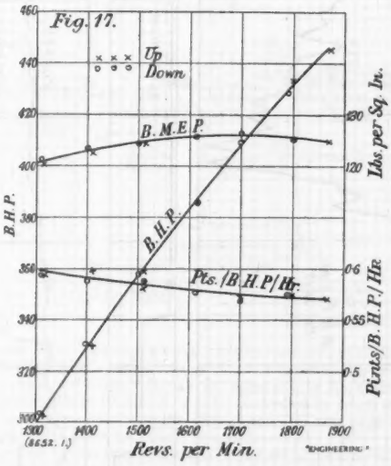


Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.



whole of the oil which collects in the crankcase is withdrawn by the scavenge pump, which is the lower one of the two above referred to, the connection for the purpose being clearly shown in Fig. 6. By the scavenge pump the oil is returned to the tank, being cooled on its way in passing through the jacket of the heater box on the induction pipe and through the chamber formed in the fan casing. This system of lubrication is claimed to be very efficient and economical, the oil consumption being given as 0·02 pint per brake horse-power hour.

Provision is made on the engine for fitting a gas starter, and sections of the distributor used with the starter are reproduced in Figs. 14 and 15. The distributor is driven from the oil-pump shaft, gas being admitted to a conical chamber at the top and delivered to the cylinders through pipe connections controlled by a disc valve. The pipe connections on the distributor are indicated in Fig. 15, and one of the non-return valves, fitted in the cylinder heads, is shown in section in Fig. 16. These valves are screwed into the cylinder heads between the two sparking plugs, the position of one of them being indicated on the centre line in Fig. 10. The upper part of the distributor itself is visible on the right of Fig. 6.

The power output of the engine has already been referred to, and further data can be obtained from Fig. 17 above. This diagram shows that the brake mean-effective pressure is a maximum at the normal engine speed of 1,700 r.p.m., reaching about 126 lb. per square inch at that speed, while the petrol consumption gradually falls from 0·6 pint per brake horse-power-hour at 1,300 r.p.m. to about 0·57 pint per brake horse-power-hour at the full normal speed. The tests from which these results were plotted were made both with the speed increasing and decreasing over the range, the co-ordinates indicated by the crosses being obtained with the speed increasing, and those by the circles with the speed decreasing. In another fuel-consumption test, carried out after the conclusion of a British Air Ministry test, a consumption of 0·525 pint per b.h.p.-hr. was obtained with the engine running at normal power and speed.

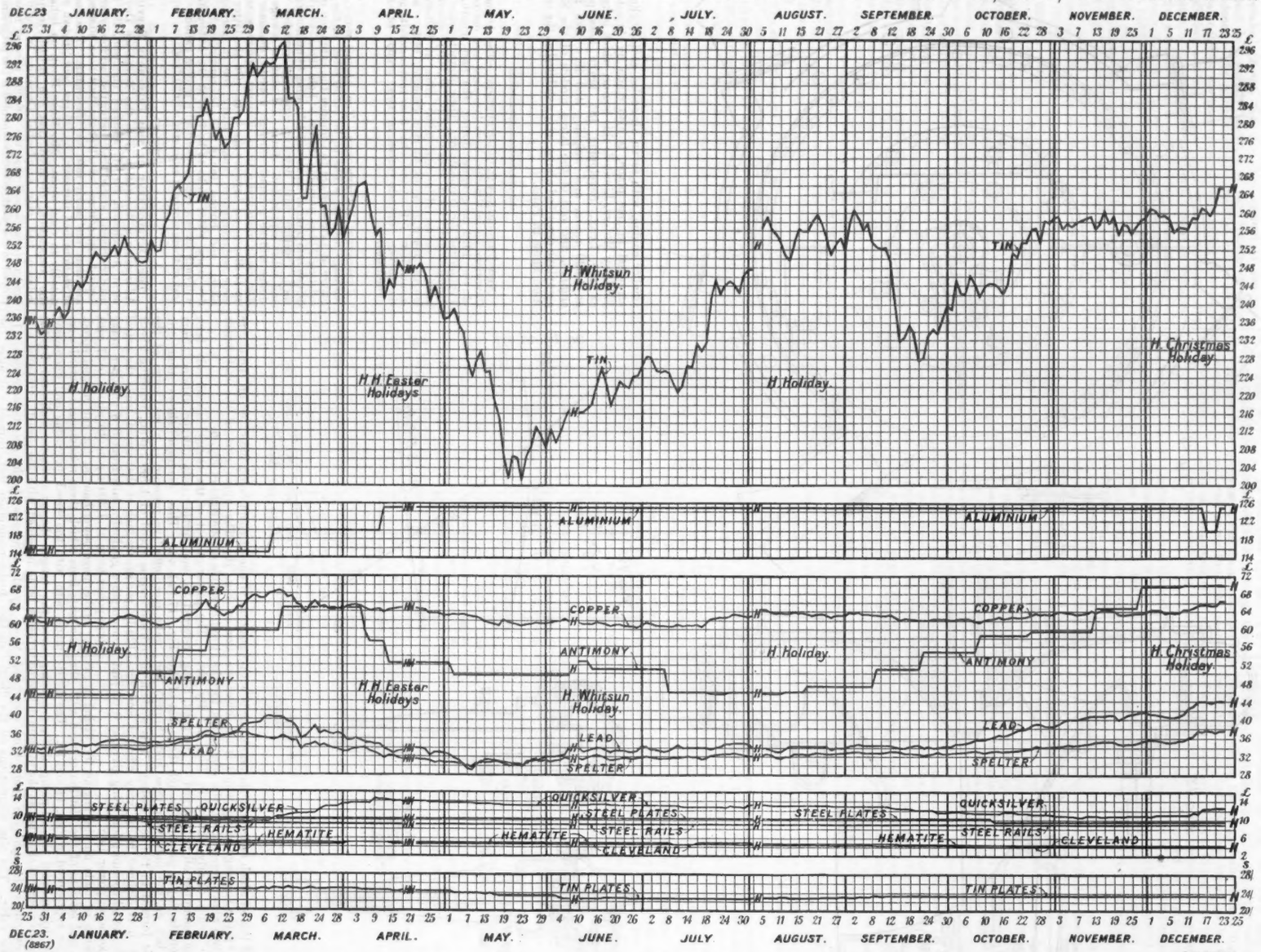
We may mention, in conclusion, that a similar but smaller engine, with seven air-cooled radial cylinders arranged in one plane, is also made by Armstrong Siddeley Motors, Limited, this engine, which is known as the Lynx, developing 185 brake horse-power at 1,620 r.p.m. and weighing 460 lb. Both these engines, and one of the latest models of the Siskin aeroplane described above, were exhibited at the recent Aero Show in Paris.

NEW FRENCH NAVAL CONSTRUCTION.—The Ateliers et Chantiers de la Gironde have launched two destroyers of the 1922 programme during the past month, the Typhon and the Tramontaine. Their characteristics are: displacement, 1,434 tons; i.h.p., 30,000; speed, 33 knots; radius of action, 3,000 miles at half-speed; length, 346 ft.; beam, 32 ft.; draught, 10 ft.; armament, four 5·1-in. and one 3-in. (anti-aircraft) guns; six 21·7-in. torpedo tubes in two groups of triple mountings.

LEICESTER WATERWORKS.—The storm water and sewerage disposal works to be constructed in the near future at Leicester are to comprise the extension of the existing Abbey pumping station to hold three electrically driven ram pumps, capable of delivering 5½ million gallons each, together with detritus tanks, an overflow weir, and other equipment. From this station sewage and sludge will be pumped, through a 44 in. diameter cast iron rising main and a 10 in. diameter pipe respectively, up to Beaumont Leys sewage farm. On the latter four large sedimentation tanks, thirty 100 ft. percolating filters, and humus tanks will be constructed. The five storm water tanks to be built at the Abbey station will each have a capacity of half a million gallons. The cost of these works is estimated at 630,700*l.*

THE DEVELOPMENT OF THE TELEPHONE SERVICE.—Addressing a deputation from the Telephone Development Association, Sir W. Mitchell Thomson, the Postmaster-General, stated that during the last four years the capital expenditure on telephones had been 30,000,000*l.* and that the yearly rate was increasing. The number of stations had increased by 20 per cent. in two years, notably in rural areas. Mr. Hugo Hirst, on behalf of the Association, declared that the British telephone industry had now supplanted Germany in supplying foreign markets, and that the 100,000 persons now employed in the work could be doubled if the programme of development was known for the next few years. The Postmaster-General intimated that despite the difficulty of securing buildings for new exchanges, the State, having taken over the services, was bound to find the necessary money for extending the service in general.

DIAGRAMS SHOWING FLUCTUATIONS IN THE PRICES OF METALS FROM CHRISTMAS, 1923, TO CHRISTMAS, 1924.



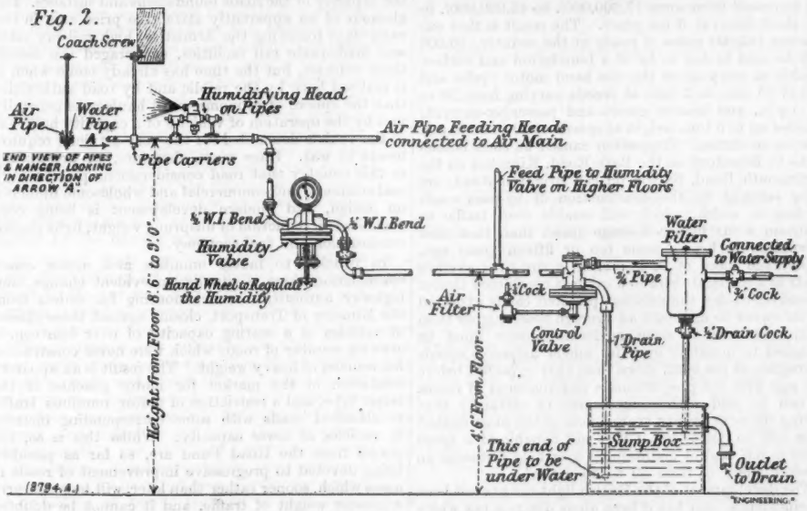
NOTE.—The figures for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices for lead are for English metal; those for spelter for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin plates is per box of I.C. cokes f.o.b. at Welsh ports; that of mercury per bottle. Other prices are per ton. Each vertical line in the diagram represents two market days, and the horizontal lines represent 2*l.* each, except in the case of tin plates, where they represent 2*s.* each.

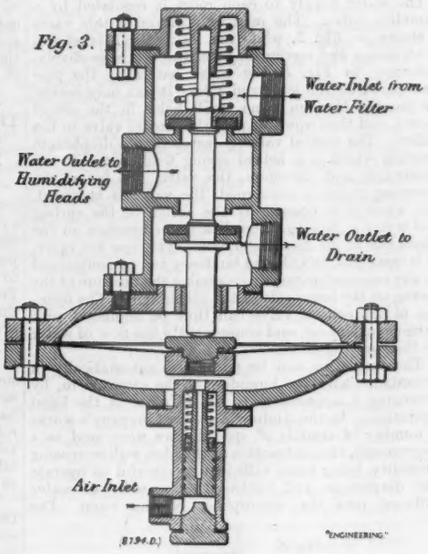
(8867)

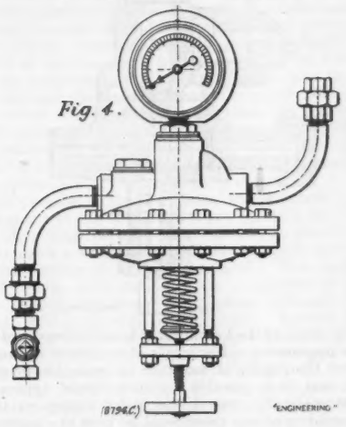
HUMIDIFYING APPARATUS FOR TEXTILE FACTORIES.

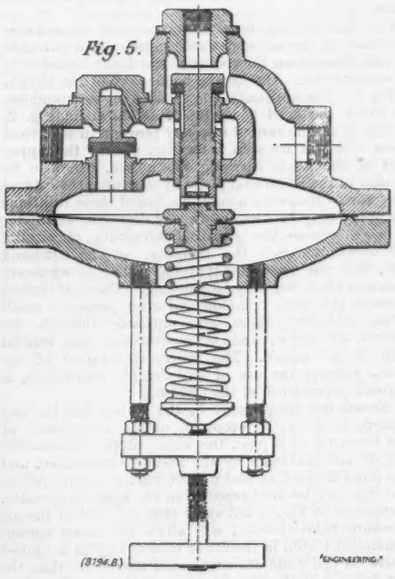
CONSTRUCTED BY THE ANDREW MACHINE CONSTRUCTION COMPANY, LIMITED, ENGINEERS, STOCKPORT.

FIG. 1.









THE ANDREW HUMIDIFYING SYSTEM.

ONE of the reasons often given for the success of the cotton industry in Lancashire is the natural moisture of the climate in that county, for it has long been recognised that textile manufacture cannot be carried on efficiently in a dry atmosphere. For the best results the moisture in the air must be maintained at a fairly definite value, and since natural conditions do not give the constancy which is so desirable, it has become the practice to instal humidifying apparatus in textile mills for the purpose of keeping the moisture content always at the required amount. With such apparatus the manufacturer is practically independent of the natural atmospheric conditions and can carry on spinning and weaving operations equally well in any climate.

In the design of humidifying apparatus, the requirements which have to be met, if the plant is to give satisfaction, are rather stringent. It must be possible to maintain any degree of humidity desirable for different operations, and the humidity of each room must be separately controllable. Instant variation, moreover, must be possible to suit changes in atmospheric conditions. The apparatus must not drip water at any point, must not take up floor space in manufacturing rooms, and in general must be simple and reliable under all conditions. The Andrew Machine Construction Company, Limited, of Oliver-street, Stockport, have devoted a great deal of attention to the question of humidification of air and have devised and patented a system which appears to meet every requirement of the textile industry. It can be arranged to be entirely automatic in its action or to be controlled by hand, and, as will be seen from the illustrations on this page the essential parts are simple in construction.

The actual humidification of the air is performed by sprays of moisture from atomising heads distributed throughout the various rooms of the mill. The photograph reproduced in Fig. 1 shows a series of such atomising heads in a room of a cotton mill. Details of the heads will be given later, when the general principles of the system have been explained. The air used for atomising is taken from the outside of the mill, through a filter, to an air compressor, which may be driven by belting from the mill shafting, or by a separate motor. The compressor delivers it through a cooler to a combined receiver and filter in which it is reduced to normal temperature and freed from any particle of oil or oil vapour that might have come from the compressor. From the receiver it is piped to the various humidifying heads throughout the mill, being treated on its way with any deodorising or disinfecting material that may be desirable.

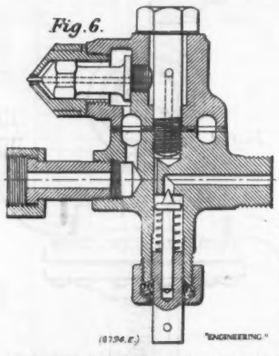
The water cannot enter the system until the air has reached a pre-determined pressure. Reference to Fig. 2 will show that the water from the mains is passed first through a filter and then to the upper part of the main control valve, a section of which is given in Fig. 3. When air pressure is insufficient, the valve is in the position shown, preventing the passage of the water to the humidifying heads and leaving the system open to the drain. The valve-stem rests on a diaphragm in the circular chamber in the lower part of the apparatus.

When the air-pressure underneath this diaphragm is sufficiently high, the valve stem is raised, the upper valve then allowing the water to flow into the system and the lower valve closing the outlet to the drain.

The water supply to each room is regulated by a humidity valve. The relative position of this valve is shown in Fig. 2, while the valve itself is shown in elevation and section in Figs. 4 and 5 respectively. Referring to Fig. 5, the water enters by the pipe connection on the left-hand side. It can only escape by passing through some small holes in the sleeve shown, and then upwards past the central valve to the outlet. The central valve is fastened to a diaphragm beneath which is a helical spring tending to lift the diaphragm and, therefore, the valve. So far as the incoming water is concerned, the valve is balanced, but when it is opened by the action of the spring, and water is flowing, there is a water-pressure on the upper side of the diaphragm, tending to close the valve. It is clear that this closing tendency can be neutralised to any required degree by increasing the pressure of the spring on the lower side of the diaphragm. The opening of the central valve can thus be regulated with extreme exactness, and consequently the flow of water to the spraying heads.

The regulation can be performed automatically in accordance with the humidity of the atmosphere, by arranging a hygrometer to act in place of the hand operation. In the Andrew Machine Company's works a number of strands of special fibre were used as a hygrometer, the contraction of the fibre with increasing humidity being quite sufficiently powerful to operate the diaphragm and control the quantity of water diffused into the atmosphere of the room. The

Fig. 6.



turning of one of the humidifying heads in the direction of the hygrometer a few yards away almost instantly reduced the supply of moisture to negligible proportions, and it is possible by such simple apparatus to automatically control the water supply so that the humidity of any room could be kept at a constant value.

The humidifying heads are mounted at suitable intervals on the air and water pipes, which run side by side throughout the rooms of which the humidity is to be controlled. One of the heads is shown in section in Fig. 6. The horizontal connections act as trunnions, on which the head is mounted, as shown in Fig. 2, so that it can be turned into any position in a vertical plane. It will be seen from Fig. 6 that the upper part of the head, carrying the nozzle, can also be rotated in the horizontal plane by loosening the central set screw. Hence by a combination of these rotations the spray may be directed in any direction whatever, so as to secure the greatest uniformity of results. Air enters through the trunnion on the left-hand side, and can reach the spraying nozzle in whatever direction the latter may be pointing. The water enters through the other trunnion and after passing a small spring-controlled valve, goes upwards through the central set screw, and thence through the central hole of the nozzle. The universal rotation of the head, without the use of any flexible connection, is a great convenience of the system.

Should the air pressure in the system fail for any reason, such as the stoppage of the compressor or the breaking of a pipe, the water supply is instantly cut off automatically by the main control valve, and the pipes drained, so that no water is left in the system, nor can any be discharged from the spraying nozzles. Reference to Fig. 3 will show that any fall in the air pressure below normal will allow the small spring-controlled piston in the lower part of the main control valve to fall from its seat, with the result that the air below the diaphragm is immediately allowed to escape freely and the upper spring to force down the central valve to the draining position shown in the illustration. This is indeed its normal position so that the pipes are kept drained, and therefore not liable to flood the mill or become frozen during the night or at week-ends. A special feature of the Andrew Plant is its cooling capabilities in times of excessive heat, and also its powers of de-humidifying where the atmosphere is subject at certain periods to heavy excesses of moisture as in India, China, &c. The compactness of the system, its self-regulating features, and its simplicity all deserve the consideration of those who are interested in the artificial humidification of buildings.

THE INFLUENCE OF ROAD CONDITIONS ON THE DEVELOPMENT OF THE MODERN MOTOR VEHICLE.*

By H. G. BURFORD.

THERE is no country in the world which can show so great an improvement in road conditions as Great Britain. Similarly there is no other country which possesses so complete a system of highways in proportion to area. The classification of roads by the Ministry of Transport and the appropriation of the revenues from the taxation of motor vehicles to grants of 50 per cent. and 25 per cent. of the costs of maintenance respectively of class I and II roads have enabled highway authorities to undertake the provision of bituminous material surfacing of probably 40,000 miles of road. The straightening of corners and by-pass road construction have proceeded apace, with the result that to-day roads are available for the lightest types of motor vehicles to travel in all parts of the country, with safety and reliability at speeds probably twice as high as could economically be maintained ten years ago.

The revenue from the old duty on motor spirit and the carriage licenses amounted to some 2¼ million sterling in 1914, while the revenue from the duties imposed on motor vehicles in 1920 is already producing some 15,000,000*l.* per annum, and the total costs of expenditure upon road improvement and maintenance has increased from some 17,000,000*l.* to 45,000,000*l.* in this short interval of ten years. The result is that out of some 185,000 miles of roads in the country, 40,000 may be said to-day to be of a foundation and surface capable of carrying on the one hand motor cycles and cars of 15 cwt. to 2 tons at speeds varying from 30 to 60 m.p.h., and heavier goods- and passenger-carrying vehicles up to 5 tons weight at speeds of 20 to 30 m.p.h. or even in excess. Congestion caused at such bottlenecks as Brentford on the Bath Road, Kingston on the Portsmouth Road, Sutton on the Brighton Road, are being relieved by the construction of by-pass roads 60 feet in width, which will enable road traffic to maintain a far higher average speed than that now prevailing. Whereas some ten or fifteen years ago, an average speed of 20 m.p.h. on a run over average roads in a moderate powered car was considered almost excessive, to-day the smallest powered car is expected by its owner to maintain an average speed higher than that, and cars of more moderate power must be designed to maintain even for longer distances speeds averaging 50 per cent. more than that expected before the war with the proportionate improvement of roads. It can be said with some degree of certainty that during the next twenty years no car of the most modest type will be demanded if it is not capable of a speed of 50 m.p.h. and of maintaining over long distances an average speed of from 30 to 40 m.p.h.

The development of the British light car has not been a coincidence—nor has it been alone due to a tax which varies with the horse-power of an engine, based on a formula which takes no account of the stroke of the pistons or of revolution speed. It is due principally to improvements in road conditions which make that type of vehicle suitable for the roads and the roads suitable for the vehicle. Complaint is not uncommon that however suitable the modern British built private car may be for conditions in this country, the comparatively primitive conditions in less populated countries demand an engine of lower speed, a vehicle of higher clearance, and of lower gearing.

The criticism has been passed on the British designer that he is not catering for a world market, which, in a free trade country, is essential to the prosperity of any engineering industry. Whatever merit there may be in such a criticism, it could equally and perhaps more logically be applied to the cause and not to the effect, and I make bold to say that the cause of any change in engine design which has taken place is the wholly revolutionary change in the road conditions in this country. While it would not be suggested that there should not be a gradual improvement in the foundation surface and alignment of roadways, there may be a danger, from the point of view of the manufacturer, in proceeding too rapidly with the development of an already comparatively superfine system of highways. In the United States of America particularly, and in France and Italy to a less degree, progress has been proceeding apace, but even so, whereas in Great Britain probably one mile of road for every thousand inhabitants is of an adequate strength to carry modern traffic under 2 tons at any speed without undue wear and tear, the proportion in America with a census of vehicles exceeding that in this country by eleven times, the mileage of really metalled and surfaced roads is probably not 1 to 5,000 of a far more scattered population. Whilst this is so, conditions are improving surely even if less rapidly throughout the world. During the past twelve months the export business in British vehicles has progressed, and the demand overseas for what may be termed the British high efficiency machine has increased by over 300 per cent. compared with 1922. As roads improve abroad, so, I venture to say, will the demand for the British made motor car increase, and the time may not be far distant when conditions for the home market in America and for the export market for her productions will force the manufacturer to develop upon a design following that adopted in Great Britain and to a less degree on the Continent.

The recent development of the design of the commercial vehicle both for goods and passenger-carrying purposes is equally interesting. War conditions forced the manufacturer to concentrate on what was virtually a standardised type of vehicle of a capacity of from 4-5 tons, which to the number of probably 100,000 were liquidated after the Armistice at prices which bore no relation to cost of manufacture. Undoubtedly the roads, which had of necessity depreciated during a period when there was neither labour nor material for improvement, were totally inadequate to maintain so abnormal a class of traffic. Probably no greater disservice was ever rendered both to the commercial vehicle manufacturer and to the highway authorities responsible for the roads, than the unloading on to the public of masses of vehicles of a capacity and weight far exceeding either the requirement of the public or the capacity of the roads foundations and surfaces. The glamour of an apparently attractive price and, in the early days following the Armistice, high railway rates and inadequate rail facilities, encouraged the use of these vehicles, but the time has already come when it is realised both by the public and by road authorities that the sphere of economic road haulage is generally met by the operation of vehicles of a capacity half that of the vehicle demanded for the very artificial requirements of war. Once more, therefore, we are finding in this country that road considerations place a very real economic and commercial and wholesome influence on design, and modern development is being concentrated on reduction of unsprung weight, light chassis construction and fuel economy.

In relation to motor omnibus and motor coach construction there is equally an evident change, and highway authorities are clamouring for orders from the Ministry of Transport, closing against these classes of vehicles of a seating capacity of over fourteen, a growing number of roads which were never constructed for vehicles of heavy weight. The result is an apparent limitation of the market for motor coaches of the larger type, and a restriction of motor omnibus traffic to classified roads with some corresponding increase in vehicles of lower capacity. Whilst this is so, the grants from the Road Fund are, so far as possible, being devoted to progressive improvement of roads in areas which, sooner rather than later, will have to carry a greater weight of traffic, and it cannot be doubted that to the degree to which these improvements are carried out the demands of the customer for larger types of passenger-carrying vehicles will increase, and will afford an ever growing field for the manufacturer. That, however, must be a matter of time, and for some years to come it is probable that the limitations of the roads will force manufacturers to concentrate more particularly on the production of vehicles of a capacity of from 15 cwt. to 2¼ tons.

It is thus that the manufacturer of commercial vehicles must look: (*a*) To the practical limitations noted in relation to road conditions applicable to-day. (*b*) to the ever-growing improvements of existing roads, and (*c*) to the construction on advanced lines of new arterial roads capable of carrying economically loads of considerable weights at comparatively high speeds. Among the latter, already in course of construction or seriously contemplated are: 1. The North Circular Road, connecting the Port of London Docks with the approaches to London on the South West. 2. The Great West Road, serving as a main avenue of approach from the Bath Road. 3. The new Cambridge Road, which will afford an alternative approach from the Eastern counties, to the congested Chelmsford-Colchester route. 4. The Glasgow-Edinburgh Road, for which preliminary arrangements have been made. 5. The Liverpool-Manchester Road, which has been surveyed and will undoubtedly be commenced within a short period. 6. The Newcastle-Tynemouth Road, in connection with ambitious town-planning schemes in that populous industrial area. 7. The Birmingham-

* Paper read before Section K, of the World Power Conference, on Tuesday, July 8, 1924.

Wolverhampton Road, which would undoubtedly be of the utmost value to one of the most thickly populated industrial districts of the country, and as regards which a start has been made. 8. The Mid-Glamorgan Inter-Valley Communication connecting two industrial districts, in South Wales.

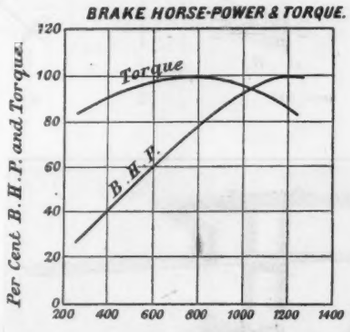
With these preliminary observations it may be opportune to consider more precisely the nature of the development of design which, as mentioned, may be attributed largely, if not entirely, and indirectly, if not directly, to the influence of road conditions. The state of the road undoubtedly has a marked influence on the amount of load which can be carried on a given vehicle, and this fact was clearly demonstrated during the military operations of 1914–1918. Many hundreds of vehicles which, in this country, had been in regular service carrying useful loads of three tons, had their rated capacity reduced to 30 cwt., when employed in France and other fields of operation. For use in Lancashire and the West Riding of Yorkshire, where roads are notoriously bad, vehicles, if they are to be successful, must be made much more robust than is necessary for service in other parts of the country, and the cost of their upkeep is considerably higher. A fair index of the relative values of good and bad roads is afforded by the known fact that, on precisely similar vehicles, the rate of tyre wear in Lancashire and the West Riding of Lancashire is from 1½ and 2½ times as great as in the South and other parts of England, where roads are good.

The limiting factors in the construction, and consequently in the total weight of a vehicle appear to be the strength of the wheels, axles and springs; these must be made robust and consequently heavy if the machines are to be regularly operated on bad roads. All these parts are unsprung weight, and it is undeniably true that it is the unsprung weight which has the greatest influence on the road, and conversely, is most influenced by bad roads. Given a good road surface on a sound foundation, a vehicle of given load capacity may have the weight of its unsprung parts safely reduced to a minimum, and there would be attendant reductions of weight in other parts of the chassis and body. The load distribution is also influenced by the state of the roads, for the reason that a surface which is dusty in dry weather is usually slimy in wet weather, and consequently the co-efficient of adhesion between the tyres and the road is very much reduced. To balance this factor the percentage of weight on the driving wheels must be greater than would otherwise be necessary in order that the required tractive effort may effectively be transmitted by the driving wheel tyres.

Ten or twelve years ago, the average resistance to rolling effort offered by the surface of main roads was about 90 lb. per ton, and there were many soft roads which offered a resistance as high as 150 lb. per ton. This necessitated a large amount of low-gear work. The average is now probably less than 60 lb. per ton on main roads, rarely exceeding 80 lb. per ton on secondary roads, and about 100 lb. to 120 lb. per ton on by-roads. Improvements in main road surfaces, therefore, have been made to the extent of about 50 per cent., but this does not mean that the power required for traction per unit load has been reduced in like proportion. Gradients remain the same, and as the laws of gravity have not been altered, the actual average reduction of power required is only about 18 per cent. On the other hand, the demands of the motoring public have become more stringent, and unless a commercial goods vehicle can now take all gradients up to 1 in 30 on top gear, and 1 in 25 for motor coaches, it stands but a poor chance against its competitors. When considering the required engine-power of a vehicle, therefore, we must keep these figures in mind. The added tractive effort which must be provided to overcome a gradient of 1 in 30 is 75 lb. per ton of load, and this figure, added to the tractive resistance on the level (60 lb.) shows that the engine must be capable of developing and transmitting to the driving wheels on top gear a tractive effort of not less than 135 lb. per ton weight of the loaded vehicle, in addition to any extra power which may be needed to overcome wind resistance. As windage does not become serious until the travelling speed exceeds 20 m.p.h., we may ignore its effect so far as commercial vehicles are concerned.

Top gear and maximum engine speed and power, however, are not synonymous with maximum engine torque. For reasons of economy, for average running an engine is usually designed to give its maximum torque at a speed much below the highest at which it is capable of running, and further, the torque curve is invariably much flatter than the power curve. For instance, an engine designed to give its maximum power at 1,200 r.p.m. would give its maximum torque at about 800 r.p.m., and from 600 to 1,000 r.p.m. the torque curve would show but very little variation, as indicated in the curves reproduced. For this reason it will be seen that it is quite practicable to discount to some extent the maximum tractive effort to be provided on top gear, and instead of 135 lb. per ton we may safely take 115 lb. per ton when the engine is giving its maximum speed and power. This provision will ensure ample power to maintain the highest desirable speed on the level, but when ascending a gradient of, say, 1 in 30, the engine speed will gradually drop to between 700 and 900 r.p.m., but its torque will actually increase up to a point with the reduction of engine speed, and tractive effort at the driving wheels will mount up to the 135 lb. or more required to climb the gradient, so that the engine will continue to pull well until the gradient is increased. It may then be necessary to change to a lower gear. Taking the foregoing values as the basis for calculation of engine power, the author has prepared a table which shows the power requirements for commercial goods-carrying vehicles of varying load capacities from one to six tons.

The loads on the front and back axles of the respective types as given in the table are the averages for a large number of vehicles of various makes, and it will be seen that in no case does the load on the back axle fall below twice that on the front axle, and this condition only for the slowest class of vehicle. This circumstance explains why the use of four-wheel braking systems have not been so widely used on commercial vehicles as on private passenger cars, in which latter class the weight carried on the two axles is usually about equal, and in even the most extreme cases the proportion does not exceed three on the back and two on the front. This relative lack



of adhesion of the private car driving wheel tyres therefore, demands that use should be made of the front wheels for assistance in braking. The greater driving axle load of a goods-carrying vehicle by providing increased adhesion ensures that its two-wheel braking is practically as efficient as the four-wheel braking systems used on private passenger cars. This divergence from the subject of engine power will no doubt be excused because of the great interest at present being taken in the use of four-wheel brakes.

Reverting to the table, it will be seen in line 6 what horse-power is required at the road wheels to produce the tractive effort stated for the same vehicle in line 4 at the speed given in line 5. As, however, there is a certain loss of power in transmission from the engine to the road wheels, we must allow for that loss in determining the power of the engine. The efficiency of different types of gear varies greatly, but we should be safe to take 85 per cent. as the average over-all efficiency on top gear, this allowance taking into account losses due to clutch, clutch-to-gear-box couplings, idle-running gears, and shafts in the gear-box, propeller-shaft couplings, final-drive gears and axle bearings. The resulting brake horse-power values, when corrected for this loss, are given in line 7. These figures for engine power, although obtained by calculation on the basis named, will be found in close agreement with the rated power of engines fitted by most well-known makers.

With regard to the private passenger type of vehicle, it is probably equally true that its development on the lines which have brought improved thermal efficiency, is due to improvements in road conditions, although to some extent this development has no doubt been influenced by the incidence of taxation. One school of thought will argue that taxation has been the dominant factor in the development of the small-bore long-stroke engine, but the writer is of opinion that this line of advancement would have occurred, taxation or not, as improvements were effected in our roads, and conversely, taxation or not, the small-bore engine would not have been adopted had roads remained in their condition of 15 years ago. It is probably merely a coincidence that the system of taxation by cylinder bore, or fuel consumption, has assisted to encourage the development on the lines now generally followed in Great Britain and Europe, and has produced the present type much earlier than might otherwise have been the case.

With regard to the fuel consumed by a vehicle engine, we are unfortunately more or less still in the hands of the petroleum producers. Strenuous efforts are constantly being made to secure greater economy, and to this end extravagant claims are being made by inventors of carburettors. Each day brings some new device, for which it is claimed that it will remove, or practically remove, the item of fuel from the list of running charges. Most of these fail lamentably to equal the performance of many of the older types, and the promises of their inventors are never entirely fulfilled. None the less, there has been steady progress both with carburettors and with engine design, and we are now able to use grades of fuel which we considered inadmissible but a few years ago. Petroleum spirit, or mixtures of petroleum spirit and benzol, form the staple fuel for motor engines, and so far as commercial motors are concerned, it is a poor machine which fails to do 45 ton-miles of work per gallon of fuel, whilst the average is probably nearly 55, and instances of over 100 ton-miles per gallon are on record. Private passenger cars are not so good in this respect, but the reasons are not difficult to find. Their gross weight is usually much lower, and the work expended in overcoming wind resistance at the higher speeds at which they run is very considerable. Improved road conditions, however, have done much to economise fuel on all classes of vehicles. During the period 1914–18, when it was imperatively necessary to conserve our supplies of petroleum spirit, much interest was directed to the use of alcohol, and mixtures of alcohol with ether, benzole and the heavier grades of petroleum, and an exhaustive and comprehensive series of tests with such fuels was carried out by the London General Omnibus Company. These tests were of a two-fold nature; first bench tests were made, and subsequently a series of road tests were carried out on about 25 London omnibuses in public service. Briefly the results of the bench tests were as follows:—(*a*) The greater the percentage of alcohol the higher was the possible thermal efficiency for the same compression; (*b*) the greater the percentage of alcohol, the higher could the pressure be raised with consequent rise of thermal efficiency; (*c*) with high compression the ill effects of valve pockets was more noticeable with small throttle openings than with low compression.

For the purpose of the road tests, the compression of the engine was raised to 160 lb. per square inch by riveting aluminium plates to the tops of the pistons, and these plates were dome-shaped so as to follow more or less the contour of the cylinder head. The best all round results were obtained with a mixture of 7 per cent. alcohol and 30 per cent. benzol, although a 50 per cent. mixture gave quite good results. Extended tests in regular service with a 50 per cent. benzol-alcohol mixture showed the cost of running for alcohol-benzol fuel, over an extended period, to be 3·5*d.* as compared with 3·3*d.* for petrol on the same type of buses, these figures being based on the assumption of equal cost per gallon of the two fuels, the figure taken being 2*s.* 1*d.* The results were particularly encouraging and, given relief from excise restrictions, there is no doubt that the production of alcohol on a large scale would do much to reduce the fuel costs of motor vehicles for both private and commercial use.

Table of Engine Power for Commercial Vehicles.
Load Capacity.

—	1 Ton.	1½ Tons.	2 Tons.	3 Tons.	4 Tons.	6 Tons.
1. Front axle weight (tons)	½	1	1½	1½	2	4
2. Back axle weight (tons)	2	2½	3½	5	6½	8
3. Total weight (tons)	2½	3½	5	6½	8½	12
4. Required tractive effort (pounds)	320	440	575	780	980	1,380
5. Speed in miles per hour	19	17	15	14	13½	11
6. Effective horse-power at tyres	16·2	20	23	29·1	35·3	47·5
7. Brake horse-power of engine, allowing transmission efficiency at 85 per cent.	19	23·5	27	34·3	41·5	54·7
8. Bore of suitable engine (inches)	3½	3½	3¾	4¼	4½	5
9. Stroke of suitable engine (inches)	5	5½	5½	5½	6	6½

Another means of improving fuel economy which has been put into practice during the past ten years, is the use of aluminium-alloy pistons, thereby reducing the weight of reciprocating parts and conducing to marked increase in thermal efficiency. The use of such alloys for vehicles would not have been practicable had our roads continued to be as dusty as they were, because the fine dust would have been drawn into the cylinders during the aspiration strokes, and would have acted as a most destructive abrasive. To prevent its ingress to the cylinders most elaborate and cumbersome air filters would have been necessary, as they now are for

the engines of agricultural tractors when working in the fields during the dry weather.

Had there been no increase in the standard of user's requirements, the general improvements which have been made in road construction and maintenance would have enabled us to use, for a given load, an engine developing approximately 18 per cent. less power than was required ten or twelve years ago. In spite of the higher standard of ability now demanded by users, however, improved roads have made it possible to meet those standards without any proportional increase in the total cost of running, although wages have doubled and in some cases trebled during the period of development, and the price of most consumable stores has increased. Tyre maintenance, which at one time cost as much as 4*d*. per mile for a four-tonner, is now down to about a quarter of that sum, and the six tyres of a modern London omnibus now cost for maintenance by contract not more than ½*d*. per mile. Pneumatic tyres are now commercially practically for goods-carrying vehicles, and on a two-tonner cost not more than 1*d*. per mile.

For the valuable information contained in this paper I am greatly indebted to Colonel Hacking, Secretary of the S.M.M.T., and also to Mr. George Watson, M.I.Mech.E., M.I.A.E., whose wide experience in consulting and practical work enables him to put forward facts which are indisputable. The industry as yet has not recognised fully the valuable research and development work which Mr. George Watson in the last twenty years has been giving to it, with very small remuneration to himself.

A NEW HARMONIC ANALYSER.*

By K. NOGUCHI.

THERE are many kinds of harmonic analysers in use, but in small patterns they have generally a low analysing power, high analysing power being obtained only with very large instruments. The new analyser devised by the author and described below is intended to obtain a high analysing power with a small and handy construction.

It is well known that the mechanical construction of harmonic analysers is much aimplified in using Henrici's Principle for the integration.

Let $y = f(\theta)$, then the two Fourier's coefficients of the nth harmonics are

$$A_n = \frac{1}{\pi}\int_0^{2\pi} y \sin n\theta \, d\theta$$

and

$$b_n = \frac{1}{\pi}\int_0^{2\pi} y \cos n\theta \, d\theta$$

Thus, to obtain these coefficients, three elements y, $\sin n\theta$ (or $\cos n\theta$) and $d\theta$ are to be mechanically combined in one way or another.

The expressions for the coefficients can be transformed by integration by parts, thus

$$A_n = \frac{1}{\pi}\int_0^{2\pi} y \sin n\theta \, d\theta =$$

$$\frac{1}{\pi}\left[-y\frac{\cos n\theta}{n}\right]_{\theta=0}^{2\pi} + \frac{1}{n\pi}\int_{\theta=0}^{2\pi} \cos n\theta \, dy$$

$$b_n = \frac{1}{\pi}\int_0^{2\pi} y \cos n\theta \, d\theta =$$

$$\frac{1}{\pi}\left[y\frac{\sin n\theta}{n\theta}\right]_{\theta=0}^{2\pi} - \frac{1}{n\pi}\int_{\theta=0}^{2\pi} \sin n\theta \, dy$$

As the terms within brackets in the above expressions which contain y can be made zero, only the two elements $\sin n\theta$ (or $\cos n\theta$) and dy are required to be taken into account. The present instrument is an integrator for integrating $\int \sin n\theta \, dy$ or $\int \cos n\theta \, dy$.

In this instrument the integration is achieved by relative motion between a horizontal plane moving in the direction of the y-axis and an integrating roller of the polar planimeter type, the shaft of which can revolve in a horizontal plane. (See Fig. 1*a*). The roller is an ordinary integrating roller, the shaft of which lies horizontally and the steel roller A touches at its circumference a horizontal plane. B is the scale showing the angular position of A, and C the scale showing the number of revolutions of the wheel A.

In Figs. 1, *a*, *b*, *c*, *d* the arrow-head shows the direction of motion of the horizontal plane touching the steel wheel A. If the relative position between the arrow-head and the shaft be as shown in Fig. 1*a*, then the wheel A will rotate so as to make its circumferential displacement equal to the displacement of the horizontal plane. At the position shown by Fig. 1 *b*, as the shaft coincides with the arrow-head, the wheel A makes no rotation. In general when the shaft makes an angle ϕ with the arrow-head (Fig. 1 *c*), and the plane is displaced by Δy, the wheel A rotates so as to make the circumferential displacement $\Delta y \times \sin \phi$. If we take ϕ' for the angle between the shaft and the perpendicular direction to the arrow-head as shown by Fig. 1 *d*, the circumferential displacement of the wheel A will be $\Delta y \times \cos \phi'$.

The present instrument is so constructed that the horizontal plane can move only in the direction of the y-axis and ϕ (or ϕ') is always equal to the phase angle $n\theta$ at every point of the wave figure, the amount of rotation of the integrating roller will therefore give the value of the required integral $\int \sin n\theta \, dy$ (or $\int \cos n\theta \, dy$).

The whole mechanism of this instrument is arranged to provide the two principal motions above mentioned, *i.e.*, the motion of the horizontal plane in the direction of the y axis and the rotation of the shaft of the integrating roller to make ϕ (or ϕ') equal to $n\theta$. Fig. 2 shows the general view of this instrument, which measures 10 cm. × 20 cm. × 35 cm.; it will be seen that the size is very small for an analyser capable of calculating high harmonics. For the purpose of explanation a skeleton diagram is shown in Figs. 3 and 4. In this diagram all rotating shafts are denoted by chain-lines. A_1 and A_2 are wheels or rollers having the same diameter, fixed to a common shaft B B′. This shaft B B′ is supported by the two arms projecting from the main frame C C′. A straight groove D D′ of triangular section is cut on the upper face of the frame C C′ and another groove E E′ of the same sectional form on the lower face, both grooves being parallel to the shaft B B′ and serving to guide the carriage F.

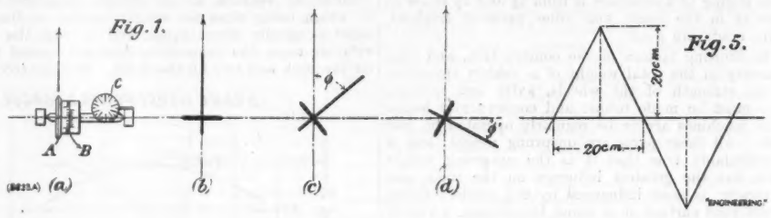
In using the instrument, it is placed so that the shaft B B′ is parallel to the y-axis of a wave figure to be analysed and the wave is then traced with the pointer W attached to the carriage F. During this operation the instrument as a whole will roll, by aid of the wheels A_1 and A_2, in the direction of the abscissa, *i.e.*, of the θ axis, owing to the θ component of motion of the pointer W. Meanwhile the carriage F, which is fitted with a horizontal celluloid-covered glass plate G G′, will move along the grooves D D′ and E E′ in the direction of the Y-axis in consequence of the y-component of the tracing motion.

The motion giving the relation ϕ (or ϕ') $= n\theta$ is obtained in the following way :—

The shaft B B′ is firmly fitted, at its middle part, with a hard steel wheel H, having a sharp and finely-toothed edge, serving as a friction roller, which rests on a ground-glass circular plate K having the vertical shaft J as its axis of rotation. When the instrument moves in the direction of the abscissa, the two wheels A_1 and A_2 will roll and in turn also the steel wheel H. Driven by the wheel H, the circular glass plate K will rotate about its axis J, and consequently a steel wheel L resting on K is also rotated about its axis; another circular ground-glass plate N resting on the wheel L will be driven by L and revolve about its vertical axis M.

Thus, through the train of the friction rollers H, K and L, the motion of the instrument in the θ-direction is transformed into the rotation of the circular plate N, and the horizontal axis Q of the integrating roller P fixed on N will rotate in a horizontal plane.

As has already been explained the relative motion



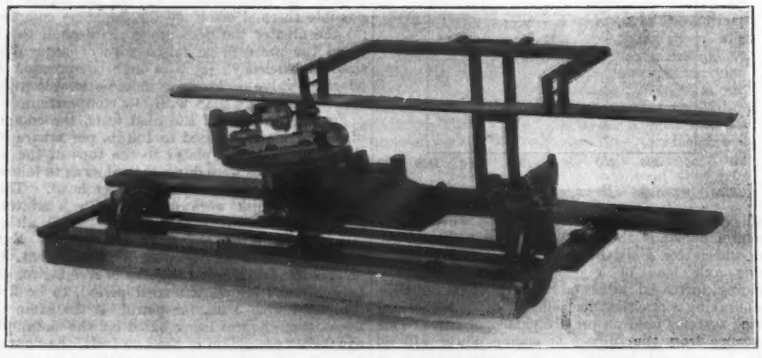


FIG. 2.

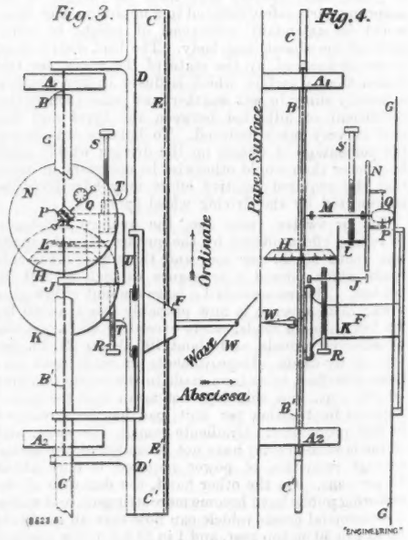


TABLE OF CALCULATED AND MEASURED VALUES.

Order of harmonics	1	3	5	7	9	11	13	15	17	19	21
Calculated Value	+162·0	−18·00	+ 6·48	− 3·31	+ 1·99	− 1·34	+ 0·96	− 0·71	+ 0·57	− 0·45	+ 0·37
Measured Value	161·3	17·90	6·41	3·27	1·95	1·37	0·97	0·70	0·59	0·45	0·36

Unit = mm.

* Paper read before the Japanese Society of Mechanical Engineers, June 19, 1924.

between the horizontal glass plate G G′ and the integrating roller P evaluates the integral $\int \sin n\theta\, dy$ or $\int \cos n\theta\, dy$. Hence, if the circular plate N makes exactly one complete revolution in tracing one fundamental wave-length, the integrating roller will give the values of $\int_{\theta=0}^{2\pi} \sin\theta\, dy$ and $\int_{\theta=0}^{2\pi} \cos\theta\, dy$, and in a similar manner, if the roller makes n complete revolutions for one wave-length, the values of $\int_{\theta=0}^{2\pi} \sin n\theta\, dy$ and $\int_{\theta=0}^{2\pi} \cos n\theta\, dy$ are given.

Therefore, in the present instrument, it is necessary that the rate of revolution of the circular disc N should be adjustable. For this purpose this instrument is provided with two adjusting screws R and S.

The screw R can, parallel with B B′, drive a sliding block on which all the components K, L, N and S are mounted. The nearer the shaft J is brought to the wheel H by this sliding motion, the quicker becomes the rotation of the disc K. In the second place, the screw S can slide the support of the wheel L parallel to B B′, so as to set the wheel L in any position between the two disc-axes J and M. Any desired ratio of rotation of the disc N to that of the disc K may be obtained by bringing the wheel L to a suitable position. Thus, the rate of rotation of the disc N is doubly adjustable by the two screws R and S.

As the instrument in actual use has only one integrating roller, two operations are required to obtain a set of Fourier's Coefficients A_n and b_n (*i.e.*, $\int \cos n\theta\, dy$ and $\int \sin n\theta\, dy$). In the one operation the integrating roller axis is made parallel to the abscissa at the start and in the other parallel to the ordinate. If rapidity is desirable, two equal integrating rollers with their axes perpendicular to each other may be used.

The instrument having the dimensions stated already, gave the following range of application: The travelling length of the carriage F or of the tracing pointer W is 30 cm., so that all wave figures with a wave height (from the crest to the trough) of less than 30 cm. can be traced by one continuous tracing. The maximum workable height, however, is not limited to 30 cm.; the analysis of a wave double this height being also possible, for waves containing only odd harmonics. In this case, the analysis of the half-wave is sufficient, so that the instrument is applicable for a total wave-height up to 60 cm. Generally, moreover, for waves having heights between 30 cm. and 60 cm., the figure may be cut by a suitable line parallel to the abscissa into two parts, and the required coefficient is obtained by summing up the indications of the integrator resulting from the two separate tracings along the upper and lower parts.

This instrument can be adjusted to analyse wave-lengths from 0·5 cm. to 130 cm. As the circular disc K and N have diameters of 7·6 cm., the distance between J and M is 4·2 cm., and the wheel L can approach to a distance 6 mm. from the axes J and M, the rotation ratio of the disc N to the disc K can range from $\frac{1}{6}$ to 6, that is, 1 to 36. As the axis J can approach the wheel H to a distance of 0·5 cm. from 3·5 cm., so the rate of rotation of the disc K varies from 7 to 1. Combining these two variations, we can so adjust one complete rotation of the disc N as to correspond to the displacement of the instrument in the θ direction, of from 0·5 to 130 cm.

From the above, it might seem possible to analyse the harmonics up to say, the 260th order $\left(260 = \frac{130}{0{\cdot}5}\right)$ for the fundamental wave-length of 130 cm., but in reality the accuracy becomes very low for very high orders of harmonics, and the following figures show what is the practical range of harmonics to be analysed.

Fundamental Wave Length.	The Highest Limit of the Order of Harmonics.
130 cm.	35
100 ,,	30
50 ,,	25
20 ,,	20
10 ,,	15
5 ,,	10

For the testing of this instrument, the author analysed the isosceles-triangular wave shown by Fig. 5, which evidently contains odd harmonics only. This special wave form was chosen in the first place to determine the instrumental error, as it is possible to eliminate a tracing error by guiding the pointer W with a straight edge, and, secondly, because in order to make a comparison, with mathematical analysis, the test wave must be mathematically suitable.

It is well known that an isosceles-triangular wave contains nth harmonics having the amplitude $\frac{8\,H_0}{\pi^2} \times \frac{1}{n^2}$, where H_0 = the height of the triangle, and

n = 1, 3, 5, ...

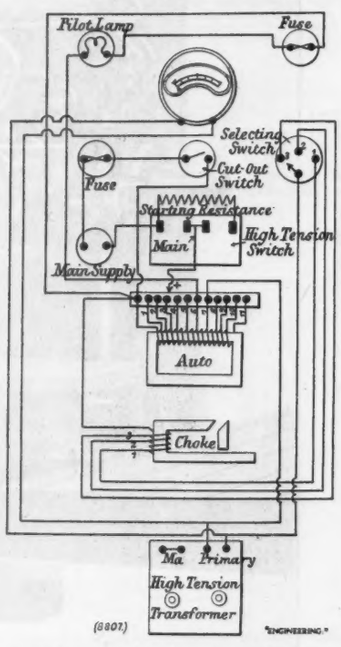
In the Table, page 876, the calculated values are obtained by putting H_0 = 200 mm. and n = 1, 3, 5, 7, ... in $\frac{8\,H_0}{\pi^2} \times \frac{1}{n^2}$, and the measured values are the mean of five measurements for each harmonics.

This result shows accurately how the instrument works, notwithstanding its small size.

In concluding this paper, the author wishes to express deep thanks to Professor Suehiro and to his colleagues in the Mitsubishi Research laboratory for their valuable suggestions and assistance.

DE LAVAL-WATSON OIL TESTING OUTFIT.

A PARTICULARLY rapid and convenient method of testing the dielectric strengths of oils is available in the apparatus recently devised and constructed by Messrs. De Laval, Chadburn and Co., Limited, of Wellington House, Buckingham-gate, London, S.W., which it is proposed to describe briefly. In making any specific determination of the insulating property of an oil the operations to be carried out using this De Laval-Watson outfit are of the simplest character. Enough of the oil is poured into a thick glass container 6 in. long, 4 in. broad and 6 in. deep to cover two $\frac{1}{2}$-in. diameter ball electrodes. These are set at a fixed distance apart and are attached to two arms,



each of which passes through a side of the vessel. The latter is then placed on an insulated table, there being, included in the arrangement, two spring conductors engaging with those of the glass container. Current is switched on and when the breakdown voltage is reached it may be read on the voltmeter provided.

The complete construction comprises a box-form angle-iron framework encased with sheet iron, into which are fitted a high tension transformer, an auto-transformer, a choke coil and a starting resistance, together with fuses and switches. The high-tension transformer is of the shell type, the core being built up of "stalloy" steel laminations each having a thickness of 0·018 in. The primary and secondary windings are concentrically wound about a centre limb, the secondary consisting of two identically similar sections. This complete transformer is contained in a galvanised iron tank and the high-tension connections are led out through two ebonite pillars fitted to the top of the transformer, the windings of which are oil immersed. Glass windows are fitted at the back and front in the casing above the transformer to permit the breakdown of the insulation to be seen. Arranged to work from a 200-volt 50-cycle supply, the auto-transformer included in the set permits the use of any normal alternating current supply. When installing the set the correct tapping is selected to suit the main supply voltage available.

Beside this auto-transformer is mounted a choke coil, accessible by removing one of the side panels of the framework. Of special design this choke control is so arranged as to ensure that under no circumstances will the current to the transformer exceed 5 amperes. Adjustment of the coil is performed by means of a large quick-running thread and wheel. One side panel forms a switchboard on which is mounted a voltmeter indicating in kilovolt root-mean-square values and reading to 100,000 volts. To the right a red pilot lamp is fixed indicating when glowing that the high-tension transformer is in operation. Underneath this lamp is a three-way switch giving three voltage ranges and full load position for the transformer. A reference to the wiring diagram, annexed, will show how this is attained. Mounted directly below the voltmeter is the main switch arranged to close the circuit through a resistance, thus eliminating the possibility of surges in the line. On the left side of the board a main supply connection plughole is provided, above which is situated a fuse holder. A handle below the main switch controls the amount of resistance in circuit. The top cover of the apparatus is of sheet metal and hinged. Working in conjunction with this is a safety device consisting of a rod and spring contact which prevents the current being switched on while the top is open. A terminal on the housing enamelled red is provided to enable the whole to be joined to earth while in operation. The complete set measures 1 ft. 6 in. square and is 3 ft. high, the weight being 2½ cwts.

CATALOGUES.

Electric Lamps.—The General Electric Company, Limited, Magnet House, Kingsway, London, W.C., have issued a priced list of Osram gas-filled lamps in clear, white and coloured glasses.

Wood Preservation.—A small catalogue dealing with a double cylinder for impregnating wood with preservatives by vacuum and pressure treatment is to hand from Mr. Grant B. Shipley, Century-building, Pittsburgh, U.S.A.

Anti-vibration Material.—Mr. P. Van Den Haute, Mont-St. Amand, Ghent, has sent us a catalogue of "trichopiese," a material of hair felt for absorbing vibration. The catalogue illustrates its application to machinery, vehicles and buildings.

General.—Messrs. Holman Brothers, Limited, Camborne, have sent us a copy of a handsome album of views of their works and products Mining and rock drilling, engines, haulage gear and general millwright work, are the main subjects. The works are on a large scale and supply plant for foreign as well as for home markets.

Electric Motors.—A new edition of their catalogue of induction motors of the squirrel-cage and slip-ring types, has been issued by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C. It includes new illustrations and additional technical information, and deals with a very full selection of machines ranging from 5 b.h.p. to 350 b.h.p.

Boiler Firing.—A catalogue of mechanical stokers, pulverised coal apparatus, air heaters, coal and ash-conveying plant, &c., is to hand from the Underfeed Stoker Company, Limited, Aldwych House, London, W.C. 2, containing general illustrations, and a long list of installations supplied by the company, which may be inspected by intending purchasers.

Electrical Equipment.—Several interesting catalogues have been received from the Westinghouse Electrical and Manufacturing Company, East Pittsburgh, U.S.A., including a general catalogue, leaf catalogues of voltmeters and trolley 'buses, and a reprint of a paper by Mr. Henry S. Day on certain essentials in dipping and baking railway motor armatures.

Electrical Machines.—Two new editions of catalogues received from the Metropolitan-Vickers Electrical Company, Limited, Trafford-park, Manchester, give very clear well-arranged and fully-illustrated information relating to the latest developments of turbo-alternators and power transformers. The transformer catalogue includes sections on general characteristics, types of construction, three-phase core type transformers, single-phase shell type transformers, special types of transformers, tanks and methods of cooling. The turbo-alternator catalogue describes the design and construction of all the principal parts of these machines and contains a long list of plants installed or on order for service at home and abroad.

Oil Firing.—Liquid fuel burning for marine and land boilers is the subject of a special catalogue issued by Messrs. Babcock and Wilcox, Limited, Farringdon-street, London, E.C. 4. The three systems—atomising by steam, air and mechanical pressure—are clearly discussed and the necessary burners, pumps and general apparatus are shown. The firm supplies complete installations on all these systems and advises as to which is best in any case when the local conditions are known. Mechanical spraying is the more efficient and practically the only one suitable for marine service and for very rapid steam raising on land; steam spraying is the simplest method, and often preferred where water is plentiful, but where water is scarce the air-pressure spraying is advantageous.

Steam and Oil Engines.—Messrs. Robey and Company, Limited, Lincoln, have sent us four catalogues of engines of various types manufactured by them. One of the catalogues deals with their enclosed-type portable engine, while another relates to crude oil engines developing from 8 h.p. to 50 h.p., with single cylinders, and from 24 h.p. to 280-h.p., with two, three or four cylinders; portable engines made in sizes ranging from 6-h.p. to 30-h.p., are also fully described with tables of capacities and dimensions. A third catalogue gives particulars of uniflow steam engines of from 60-h.p. to 1,000-h.p., all of which are capable of sustaining heavy overloads. The remaining catalogue is devoted to electric-winding engines, giving a full description of the engine and drum and also of the safety devices which form so important a feature of these engines.

HORIZONTAL MILLING, BORING, DRILLING AND TAPPING MACHINE.

Horizontal milling, boring, drilling and tapping machines commonly fall into two categories. One class includes machines with traversing tables (usually compound), while the other embraces large tools with fixed work tables and a traversing column. In both classes the saddle carried by the column is capable of vertical adjustment or automatic traverse on the column slides, while the arrangement of speeds and gears makes the machines suitable for the large range of work implied by the somewhat cumbersome name allotted to this class of tool.

For many years Messrs. Kendall and Gent, Limited, Manchester, have included in their specialities various types and sizes of horizontal milling, boring, drilling and tapping machines, and the accompanying illustration shows one of their latest designs. This machine will be seen to be of substantial construction, and is able to carry out heavy milling and boring without vibration. As will be seen, the tool is of the fixed table and traversing column type. A feature is the feed arrangement for milling or quick traversing the upright and saddle, whereby it is possible to traverse the upright along the bed by power and at the same time move the saddle up or down by hand to follow an irregular facing when milling or *vice versa*, viz., self-acting the saddle on the upright and working the column, by hand, along the bed. This is accomplished by having two independent sets of shafts, gears, &c., one to actuate the column and the other effecting the motion of the saddle on the column. For certain milling operations this combination has been found to be indispensable, and the firm have, therefore, decided to incorporate this feature in all future machines.

The spindle, 4¼ in. diameter, has a traverse of 36 in. for boring and drilling and a vertical and horizontal adjustment of 6 ft. by 8 ft. respectively; either of the latter may be altered to suit particular requirements. All change-speed and feed gears are carried on the saddle and are of high carbon steel running in oil-tight casings, nothing appearing outside the saddle except the levers and hand wheels necessary for manipulating the various motions. All motions can be operated (including the changing of spindle speeds and feeds), whilst the workman is standing on the platform, thus enabling him to keep the work constantly in view.

The drive is by a 12-h.p. constant-speed motor, through friction clutches to gearing on the saddle. There are 18 changes of speed, varying from 10 r.p.m. to 230 r.p.m. in either direction. When tapping, provision is made for running the tap back at three times the tapping speed, this being accomplished without causing shock to the working parts. The reversing motion to the spindle is obtained through powerful friction clutches. Milling feeds are available in nine changes, varying from 1 in. to 6 in. per minute, while the feeds for boring and drilling have six changes. Quick power motions are also provided for the vertical and horizontal traverses to assist in setting the work. The actual machine now illustrated and described above is geared for accurate milling, drilling and tapping and medium diameter boring and facing with spindle speeds from 10 r.p.m. to 230 r.p.m.

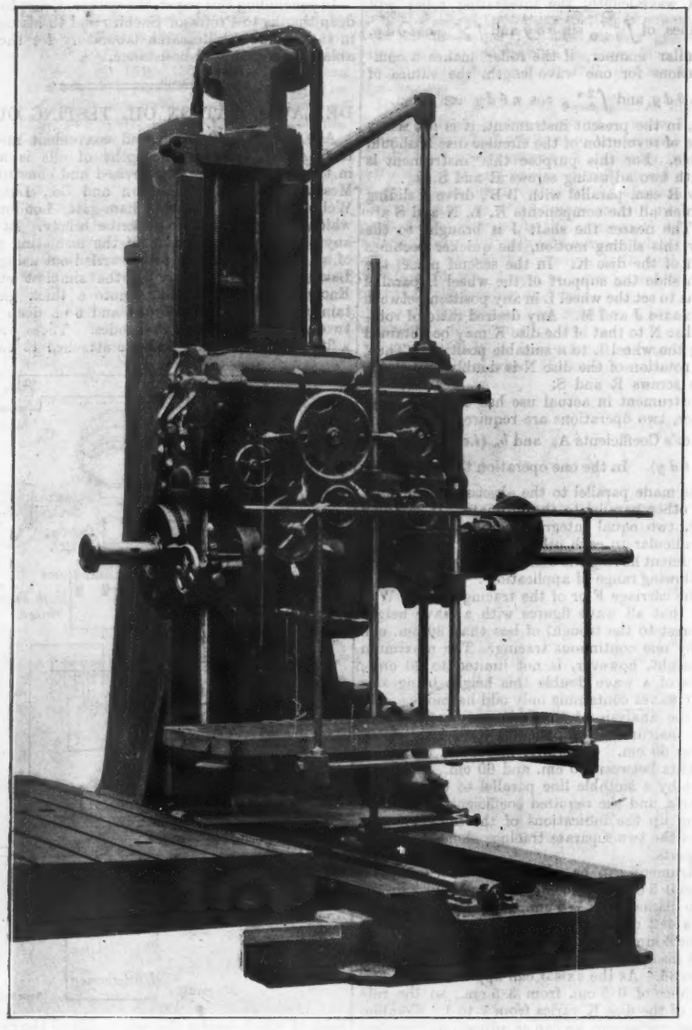
The machines can be supplied in various sizes, ranging from 4 in., 4½ in., 5 in. to 6 in. diameter of spindles. They are also made, when required, with slower spindle speeds for boring larger diameters. The spindle speeds for the machine corresponding with that mentioned above would be 5 r.p.m. to 180 r.p.m.; when made in this form no motion for the quick return of the tap is supplied.

These machines are constructed to withstand continuous heavy duty, all the gearing being of steel and all shafts of high carbon steel and of large size, running in long gun-metal bearings; these features, combined with the handy arrangement of the control handles, constitute a very high-class tool, which, as our illustration shows, is very workmanlike in appearance. Portable machines on similar lines are also made, with tackle for lifting, fixed on the top of the upright.

Rapid Installation of Boiler Plant at Bath.—A notable achievement in rapid boiler construction and installation has just been completed by Babcock and Wilcox, Limited, for the Bath Corporation. At the beginning of last October the Electricity Department found themselves in difficulties owing to delays in connection with their building work, in consequence of which the new steam plant which they had arranged for could not be installed. Under these circumstances the engineer, Mr. Francis Teague, got into communication with Messrs. Babcock and Wilcox, who prepared a scheme showing the possible installation of a 25,000-lb. oil-fired boiler in a corner of the existing boiler house, a complete equipment of burners, tanks, pipe connections and other details being included in the scheme. The order was placed on October 20, and Messrs. Babcock and Wilcox completed the installation by midnight on December 4. The following day the new unit took over the town load, and is now in regular service.

HORIZONTAL BORING, DRILLING AND TAPPING MACHINE.

CONSTRUCTED BY MESSRS. KENDALL AND GENT (1920), LIMITED, MANCHESTER.



The Institute of Patentees.—Lord Askwith has consented to be President of the Institute of Patentees for the year 1925-26.

Artificial Lighting.—We have received two excellent photographs of the turbine shop of the Brush Electrical Engineering Company, Limited, of Falcon Works, Loughborough, one of which was taken, at 2 a.m., with the aid of "Maxlume" reflectors, supplied by Messrs. Veritys, Limited, of Victoria Works, Aston, Birmingham, and the other at 2 p.m. in the afternoon, by daylight. The similarity of the results attained in each case is remarkable and testifies to the success of the reflectors used.

Swansea Metal Exchange Report.—The Market Report issued on December 16 by the Swansea Metal Exchange states that, while there is very little new business being transacted in the tinplate department, there is a slight improvement in the number of inquiries for price quotations. At a recent meeting of manufacturers it was decided that the Stabilisation Committee should continue in existence for another year. Despite only moderate demand prevailing for galvanised sheets prices remained unchanged.

University College Engineering Society.—The annual dinner of the London University College Engineering Society will be held at the college on January 26, 1925. Sir Alexander Kennedy, who was Professor of Mechanical Engineering from 1874 to 1889, will preside, while his successor, Professor T. Hudson Beare, who occupied the position until 1901, will also be present. Past and present members of the Engineering Society who wish to attend the dinner should apply for tickets to Mr. R. B. Winton, Hon. Secretary of the Engineering Society, at the college.

The Surveyors' Institution.—The annual country meeting of the Surveyors' Institution for the year 1925 will be held in Liverpool from June 24–27. The Daniel Watney travelling scholarships, under the jurisdiction of the Institution, have been awarded to Messrs. E. P. Weller, Professional Associate, University of Bristol the author of the paper on agricultural costing recently read at the Institution, and Mr. H. I. Richmond, Professional Associate, Dinams Estate Office, Llandinam, Mont., the two candidates who headed the list in forestry at the Final Examination in March last.

Standard Keys and Keyways.—The British Engineering Standards Association has just issued Publication No. 46, Part I, 1924, "Tables of Dimensions for Rectangular and Square Parallel Keys, Keyways and Key Bars." Comparing these tables with those in the original Publication No. 46, 1909, it is evident that the range of sizes for which each key was recommended has been reduced. Explanatory notes and diagrams accompany the tables in the new specification, which may be had from the B.E.S.A. Publications Department, 28, Victoria-street, London, S.W. 1, price 1*s.* 2*d.* post free.

Steel and Iron Report.—With the approach of the Christmas holidays trading in iron and steel has become almost negligible, but the feeling at the weekly meeting of the London Iron and Steel Exchange on December 16 was optimistic regarding the prospects of business in the New Year. A fair amount of inquiry is beginning to come forward from overseas markets. There has been a slight weakness in pig iron quotations, but producers on the North East Coast and some of the Midland makers are well sold into the early months of 1925. Japan has been purchasing steel sheets, but Indian buying has been hampered by the heavy duties recently imposed on material of this class.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AGRICULTURAL APPLIANCES.

221,978. H. McLaren, Leeds. Disc Cultivators or Harrows. (4 *Figs.*) October 26, 1923.—The invention relates to disc cultivators or harrows. According to the invention, the cultivator or harrow is provided with stationary devices extending across on each side of each disc at a distance from the edge equal to, or exceeding the depth to which the discs are to penetrate the ground, these devices being such as will act also as guards to prevent loose straw or trash reaching the shaft or axle carrying

Fig. 1.

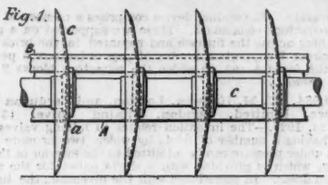
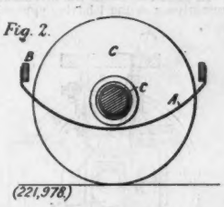


Fig. 2.



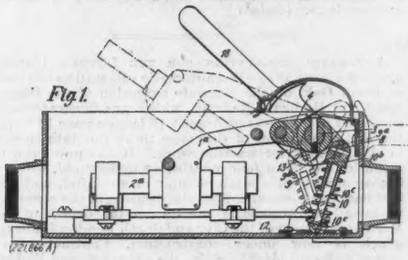
(221,978.)

the discs. The device consists of a trough A secured to the frame B of the cultivator or harrow, the trough A being transversely slotted at *a* for the passage of the lower portion of the discs C (secured to the shaft *c* in any suitable number) so that the edges of the slots *a* act as scrapers for both sides of the discs C and the trough A acts also as a guard to prevent loose straw or trash from wrapping round the shaft or axle *c* carrying the discs C. (*Accepted October* 1, 1924.)

ELECTRICAL APPARATUS.

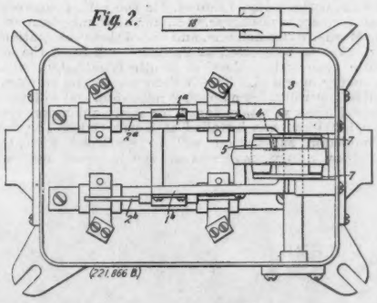
231,866. The Cable Accessories Company, Limited, Tividale, Tipton, and A. Crawford, Tividale, Tipton. Electric Switches. (2 *Figs.*) June 19, 1923.—The invention relates to electric switches of the quick make-and-break type. The contact blades 2*a*, 2*b* are moved through arms 1*a*, 1*b* mounted to rotate upon a main operating spindle 3 into and out of contact with spring contacts. Mounted upon the spindle 3 between

Fig. 1.



(221,866 A)

Fig. 2.



(221,866 B)

the arms 1*a*, 1*b* is a T-shaped crank 4 having a head 5. A lever 7 is mounted on each side of the crank 4, the levers 7 having arc-shaped slots 13 through which the spindle 3 passes. Each lever 7 is pivoted at one end to the head 5 of the crank 4, the other ends of the levers being connected together by a spindle 8, whose ends extend through the lever and engage with cam faces 9 formed on the arms 1*a*, 1*b*. Secured to the spindle 8 is one member 10*b* of a telescopic element, the other member 10*c* of which is pivotally connected to the base 12 of the switch casing. The members 10*b*, 10*c* are embraced by and acted on by a compression spring 10. The longitudinal axes of the crank 4 and levers 7 are arranged at an angle to one another such that the spindle 8 is located on one side of a vertical plane passing through the axis of the spindle 3 when the switch is closed; and on the other side thereof when the switch is open, while the pivotal point of the telescopic element is disposed in the vertical plane and directly beneath the axis of the spindle 3. The cams 9 have terminal abutments 9*a*, 9*b* so arranged on opposite sides of the spindle 3, and in operative engagement with the spindle 8 as to ensure a positive action during the opening and closing operations should the spring 10 fail to act. Assuming that the contacts are in the closed position, the action of breaking contact is as follows:—Upon the initial rotation of the spindle 3 by the handle 18, the levers 7 move about the spindle 8 as a pivot until the lost motion between the spindle 3 and the lower end of the arc-shaped slot 13 is taken up, whereupon the spindle 8 is moved about the spindle 3 as a fulcrum from its position bearing against the terminal abutment 9*a* of the cam 9 into a position in which it bears against the other terminal abutment 9*b* of the cam. Upon a continued rotation of the spindle 3, the spindle 8 bears against the cam abutment 9*b* and raises the blade supporting arms, if needs be, without the assistance of the spring 10, until contact is broken. During the initial part of such action, the spring is compressed by the abutment 9*a* until the spindle 8 passes over the dead centre of movement, thereupon the spring 10 comes into operation and effects the quick breaking action between the contact blades 2*a*, 2*b* and their respective contacts. The operation of closing the switch corresponds to the operation of opening described. (*Accepted October* 1, 1924.)

221,838. The British Electric Plant Company, Limited, Longcarse, Alloa, and A. W. Maudling, Longcarse, Alloa. Dynamo Electric Machines. (2 *Figs.*) April 16, 1923.—The invention relates to the ventilation or cooling of dynamo electric machines of the totally enclosed type in which cooling air from the surrounding atmosphere is circulated through axial passages in the stator core. In accordance with the invention,

Fig. 1.

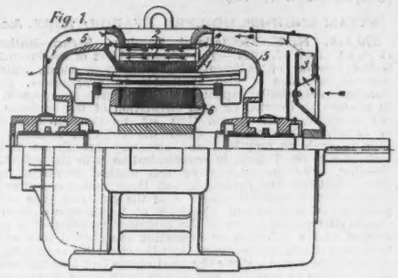
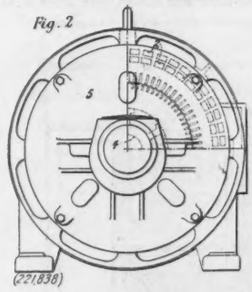


Fig. 2



(221,838)

there is provided in the body of the core a number of circular rows of elongated slots 2 spaced apart in a radial direction through which atmospheric air is impelled by a fan 3 secured to the rotor shaft 4. End brackets 5 enclose the rotor and serve to isolate the passages 2 from the interior of the machine so that these passages are supplied with cooling air only from the atmosphere. (*Accepted October* 1, 1924.)

221,844. H. V. Higgitt, London, and The Eastern Telegraph Company, Limited, London. Electric Motors. (4 *Figs.*) May 17, 1923.—The invention has for its object to obtain an intermittent rotational movement of a shaft by means of the action of an electromagnet upon an armature. A disc *a* of iron is mounted upon a shaft *b*. Loose upon the shaft on both sides of the disc *a* are armature members *c*, *d*, formed as

Fig. 1.

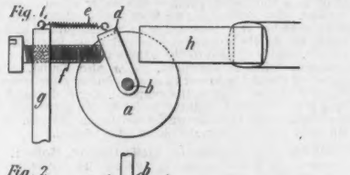
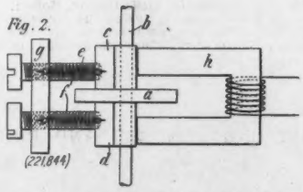


Fig. 2.



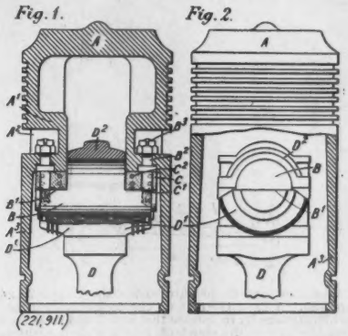
(221,844)

radial arms, each arm normally being held by a tension spring *e* against an adjustable stop (conveniently screws *f* mounted on a fixed pillar *g*). Adjacent the armatures *c*, *d*, and embracing the disc *a*, are disposed the two limbs of an electromagnet *h*, the arrangement being such that the armatures *c*, *d* are capable of rotation about the axis of the shaft *b* between the limit imposed by the fixed stops *f*, *f* and the limit imposed by the pole faces of the electromagnet limbs. Under conditions when the electromagnet is not energised, the disc and its shaft are free to rotate and the armatures *c*, *d* are held against their respective stops by the tension springs *e*, *e*. Upon energisation of the electromagnet *h* the resulting magnetic field will cause the two armatures *c*, *d* intimately to engage the disc *a* by moving axially, if necessary, and at the same time will cause them to rotate about the shaft *b*, with the result that the disc *a* will be dragged through a certain angle corresponding to the limits explained above. Upon cessation of the magnetising current in the electromagnet winding, the attraction between the armatures *c*, *d* and the magnet pole faces will cease and the armatures will be drawn back against their stops by the springs *e*, *e*. This backward movement of the armatures, however, will not impart any movement to the disc, since the adhesion between them and the disc will have ceased with cessation of the magnetising current. (*Accepted October* 1, 1924.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

221,911. William Beardmore, Lord Invernairn, Westminster, London, and A. E. L. Chorlton, Westminster, London. Internal Combustion Engines. (4 *Figs.*) July 13, 1923.—The invention relates to the construction and arrangement of a bearing member between the piston and the connecting rod, and, according thereto, the bearing member is so constructed and arranged that the whole of its lower surface is available as a bearing surface, means being provided for insulating the bearing member from the heat of the piston. The piston A has two diametrically opposite inward projections A^1 formed in such a manner as to leave external recesses A^2 in the piston wall. The bearing member B is in the form of a gudgeon pin of substantially cylindrical shape and has a length sufficient to extend right across the available space within the piston skirt A3. The upper portion of the pin B is cut away at both ends to form flat surfaces B^1 where it can be secured to the piston A. The gudgeon pin is disposed within the piston in such a manner that

Fig. 1. *Fig. 2.*



(221,911.)

its two flat surfaces B^1 lie below the two internal projections A^1 on the piston A, and is secured to these projections by means of studs B^2, which extend through to the external recesses A^2 and are held in position by means of nuts B^3 disposed in the recesses A^2. Between the lower surfaces of the projections A^1 and the flat surfaces B^1 are disposed blocks C of heat insulating material, these blocks having grooves C^1 cut in their lower surfaces to form air gaps, thus further obstructing the passage of heat from the piston to the gudgeon pin. Further air gaps may also be provided by drilling the blocks B with transverse holes C^2. The connecting rod D is formed at its upper end to engage with the gudgeon pin B, and is shaped to correspond to the cylindrical portion of the pin. This shaped part D^1 extends for the whole length of the lower surface of the pin and has connected to it a narrow strap D^2 engaging with the short cylindrical upper surface of the gudgeon pin B between the two cut-away portions. (*Accepted October* 1, 1924.)

LIFTING AND HAULING APPLIANCES.

222,034. Lobnits and Co., Limited, Renfrew, and H. O. Bedgood, Renfrew. Drag Line Excavators. (6 *Figs.*) February 25, 1924.—The invention relates to what are known as "drag-line" excavators. According to the invention, the bucket hoisting rope passes over a single pulley at the end of the boom or jib and so connected therewith that it can swing freely both laterally and longitudinally of the boom. The bucket is provided with a duplex or parallel hoisting rope 21, which passes over a duplex pulley 22 carried on the end of the boom 5 and thence to the hoisting drum. The pulley 22 is mounted on a pin 23 in the block 24 which has three arms 24*a*, 24*b* and 24*c*, the block being made up of two side plates joined together. A

Fig. 1. *Fig. 2.*

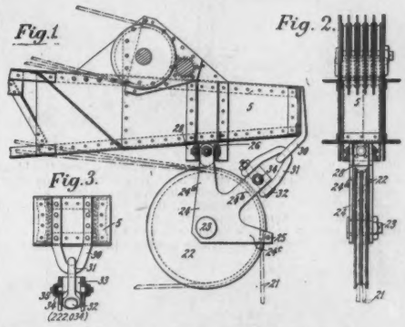
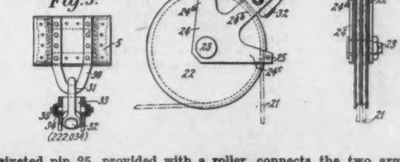


Fig. 3.

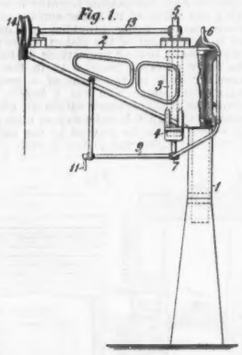


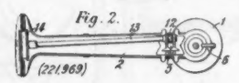
(222,034)

riveted pin 25, provided with a roller, connects the two arms 24*c* and prevents the duplex rope 21 leaving the pulley. The block 24 is connected to the boom 5 by a connection comprising a block 26 pivoted to lugs 28 depending from the boom, the block having projecting trunnions upon which are pivoted the arms 24*a* of the block 24. In this way the block 24 is free to swing both longitudinally and laterally of the boom so that it can readily accommodate itself to a change in position of the bucket relatively to the boom. In order to make the suspension of the hoisting pulley more stable, without detracting from its freedom of movement, it is also connected to the boom by its arms 24*b*, which are pivotally jointed by pins 32, 34 to a shackle

31 secured to the fixed eye 30 at the end of the boom. The shackle 31 is pivoted at its lower ends by means of the pin 32 to a block 33 (see Fig. 3) provided with a pin or trunnion 34 journalled in bearings in the arms 24b. The ends of the trunnions 34 are reduced and screwed at 35 and are provided with washers, nuts and split pins. It is obvious the pivoted joint permits the pulley to swing laterally with regard to the boom, while, when the pulley swings longitudinally about 29 the shackle 31 can work freely in the eye 30. (*Accepted October* 1, 1924.)

221,969. E. Graham, Ealing, and W. Chipperfield, Old Southgate. Jib Cranes. (3 *Figs.*) October 13, 1923.—The invention refers to a jib crane, particularly suitable for lifting work and placing same on a machine and for removing the work therefrom when finished. The jib crane, according to the invention, comprises a jib arm 2, one end of which is mounted to revolve on the upper end of a fixed vertical standard 1 from which it extends laterally, and carrying adjacent to the standard a vertical pressure cylinder 3. The cylinder 3 contains a piston 4, the piston rod 5 of which is formed with gear teeth and extends through the upper end cover of the cylinder. A pipe 6 conveys pressure fluid through a cock 7 into the base of the cylinder, and a cock-operating rod 9 is fitted, extending

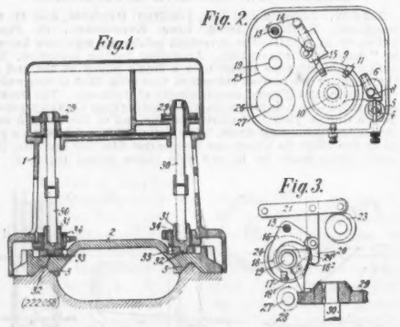




from the cock towards the outer end of the jib arm 2 and carried therefrom. A hand lever 11 on the cock-operating rod 9 fulfils two offices, namely, to operate the cock 7 and to swing the jib 2 about the axis of the standard 1 to a desired position. Upon the rise of the piston 4 in the cylinder 3 the gear teeth of the piston rod 5 engage and operate mechanism carried by the jib arm, by which, through the medium of a chain or cable, the work or weight is lifted. In a preferred construction, a revolving shaft 13 is mounted in bearings on the jib arm 2, a pinion 12 on the shaft engaging the teeth of the piston rod 5, while a drum 14 on the outer end of the shaft carries a chain or cable fitted with a gripping device to engage the article to be raised. (*Accepted October* 1, 1924.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

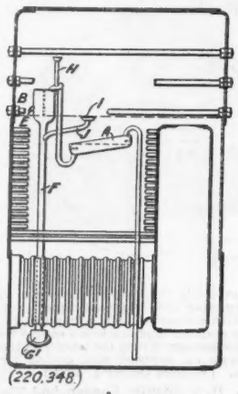
222,058. David Brown & Sons (Huddersfield), Limited, Lockwood, Huddersfield, A. Sykes, Lockwood, Huddersfield, and H. E. Kitchen, Lockwood, Huddersfield. Gear Cutting Machines. (3 *Figs.*) May 19, 1924.—The invention has reference particularly to the feeding of the cutter or cutters towards the blank to increase the depth of the cut. 1 is a cutter head carrying the cutter (not shown) and mounted on an anchor



slide 2 movable on ways 3, 3 towards and away from the blank. It is to the moving of the cutter head 1 relatively to the slide 2 on which it is mounted that the invention relates. According to the invention, a shaft 4, Fig. 2, driven at a speed suitably proportionate to that of the cycle of the cutting operation is provided with an eccentric 5 adapted to give swinging movements to a lever 6. The lever 6 carries a pawl 8 adapted to engage the teeth of a ratchet wheel 9 mounted on a shaft 10. This ratchet wheel carries a series of adjustable dogs 11 spaced apart circumferentially at appropriate distances. These dogs serve to divide up the total depth cut into a series of steps as will be apparent later. Fast upon a shaft 13 is a lever 14 adapted to be actuated so as to rock the shaft in the direction of the arrow by an abutment 15 when the latter is moved by the passage thereunder of one of the dogs 11. Also fast upon the shaft 13 is a lever 16 (see Fig. 3), the ..ne arm of which carries a block 17 adapted to co-operate with a member 18 mounted loosely upon a shaft 19, and which will be referred to as the interrupter. This interrupter has a projection 18¹ adapted to be engaged by the block 17, and a second projection 18² adapted to engage a pawl 20. This pawl is carried by a lever 21 operated continuously throughout the cutting operation by an eccentric 23. The pawl 20 engages the teeth of a ratchet wheel 24 fast on the shaft 19, when permitted to do so by the interrupter. During the time the abutment 15 is not being actuated by one of the dogs 11, the block 17 engages the projection 18¹ of the interrupter and causes the projection 18² to hold the pawl 20 in an inoperative position, so that it makes its movements idly and without engaging the ratchet 24. When, however, the shaft 13 is rocked by the passage of a dog 11 under the abutment 15, the block 17 carries around the interrupter and moves the projection 18² clear of the pawl 20, permitting the latter to operate on the ratchet 24 and step shaft 19 round. Fast upon the shaft 19 is a change gear 25 which meshes with a change gear 26 fast on a shaft 27, and this shaft 27 carries worms 28, 28 which mesh with worm wheels 29, 29 fast on vertical shafts 30, 30. It follows that during the time the ratchet wheel 24 is being stepped around by pawl 20, the shafts 30, 30 are rotated by an amount dependent upon the period of rotation of the ratchet wheel 24 and upon the ratio of the change gears 25, 26. Each shaft 30 has fast upon its lower end a cylinder 31 provided with an eccentric pin 32, and these pins 32 rotate in blocks or dies 33, 33 which fit in slots formed in the anchor slide 2 at right angles to the ways 3. The cylinders 31 work in bushes 34 carried by the cutter head 1, and it follows that as the shafts 30 and, consequently, the cylinders 31 are rotated, the effect of the eccentric pins 32 is to move the cutter head longitudinally upon the anchor slide. (*Accepted October* 1, 1924.)

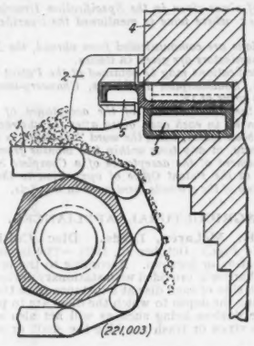
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

220,348. N. E. McClelland, London. Steam Boilers. (3 *Figs.*) April 13, 1924.—The primary object of the invention is the removal of sediment and scum from steam boilers, but the invention is also applicable to evaporators, juice clarifiers and similar apparatus. The method adopted is to produce an internal or local circulation of the contents of the boiler, lead the stream thus set up through a settling or collecting chamber, and expel the collected sediment at such intervals as may be found necessary through an outlet, such as a blow-off cock, in communication with the collecting chamber. The means whereby this method is carried into effect constitute the invention, and these means comprise, in combination, a liquid circulator A of the pulsating type which produces an intermittent discharge of liquid drawn from a comparatively cold region of the container in which it is submerged, and a collecting or separating chamber B into which the pulses or surging discharges from the circulator are delivered, preferably at a point above the level of the liquid in the boiler. This chamber is provided with means, such as an arrangement



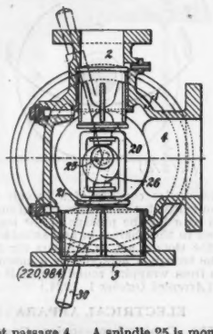
of baffle plates or a diaphragm, for arresting the velocity of the stream from the circulator A and facilitating the separation of the sediment, and with an outlet E for the water or other liquid above, at or below the level of the surrounding liquid. The lower end of the separating chamber B is connected by a pipe F with a blow-off cock or with a chamber G¹ tightly enclosing the inside end thereof, the cock being situated preferably at or near the lowest point of the water space of the boiler or the like. The discharge pipe from the circulator A to the separating chamber B is provided with a vent pipe H extending upwards to obviate stoppage of the pulsating circulator if, through neglect, mud is allowed to block the water outlet of the separating chamber. This arrangement, it is also found, enables the pulsating circulator to work faster. One or more scum pans I at the level of the liquid in the evaporator or boiler, and connected by a pipe or pipes J with the sediment discharge pipe F, enables the scum, if any, to be drawn off and discharged with the collected sediment when the latter is blown off. (*Sealed.*)

221,003. A. W. Bennis, Little Hulton, Bolton. Furnace Grates. (3 *Figs.*) June 1, 1923.—The invention relates to furnace grates of the type in which means are provided to prevent leakage of hot gases from a furnace into the ash-pit at the back of a moving chain grate and, at the same time, prevent leakage of air from the ash-pit into the combustion space of the furnace. According to the invention, what may be termed a dumper bridge or sealing device 2 is provided laterally across the furnace slightly above the level of the chain grate 1 with the object of banking up the fuel and clinker on the back end



of the grate. The sealing device comprises a number of detachable refractory elements 2. These are supported on a girder 3 stretching across the furnace and mounted in the brickwork 4. The girder 3 supports a number of pegs or hangers 5 projecting into the furnace and on which the refractory blocks 2 can be slid. (*seale...*)

220,984. C. M. Hadwen, London, and Ferguson Superheaters, Limited, London. Mixing Valve. (3 *Figs.*) May 23, 1923.—The invention relates to mixing valves of the type having a number of inlets by which two or more gaseous fluids under pressure can be admitted to the interior of the valve casing, which is provided with a single outlet for the mixture of such fluids. In accordance with the invention, the improved mixing valve comprises a casing 1 having opposed inlet passages



2, 3 and an outlet passage 4. A spindle 25 is mounted to rotate in the casing 1 between the inlet passages 2, 3 and has a cam or eccentric 26 thereon. The spindle 25 is rotated by a handle 30. A valve 20 is associated with the inlet passage 2 and a flow regulator 21 is associated with the inlet passage 3. The flow regulator 21 is so constructed or arranged that it is incapable of completely closing the passage 3. The valve 20 and flow regulator 21 are in contact with and operated by the cam or eccentric 26. (*Sealed.*)

Automatic Sub-station for the London Underground Railways.—The automatic sub-station installed at Burnt Oak, on the Edgware extension of the Hampstead and Highgate Railway, which was illustrated and described in our issue of August 15 last on page 227, was the first sub-station of this type to be put into service in this country for traction work. It has now been in operation for about four months, we understand, without the occurrence of a hitch or fault of any kind, and this fact has doubtless influenced the decision of the company to install an automatic sub-station for operating the Morden extension of the City and South London Railway, which is now under construction. Contracts have recently been placed with the Metropolitan-Vickers Electrical Company, Limited, for the rotary converters, transformers, switchgear, &c., for two sub-stations for the Morden extension line, and one of these sub-stations—viz., that to be erected at Balham—will be of the automatic type; the other, at South Wimbledon, will be manually operated. The Balham automatic sub-station will be controlled from South Wimbledon, and will contain three 1,500-kw. rotary-converter sets, as compared with two 1,200-kw. sets installed at Burnt Oak. The South Wimbledon sub-station will be equipped with three 1,200-kw. rotary converters and the necessary auxiliaries.

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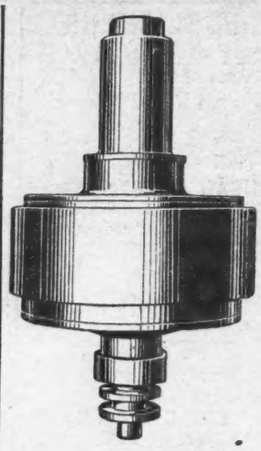
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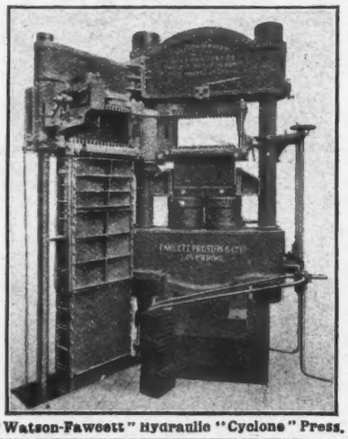
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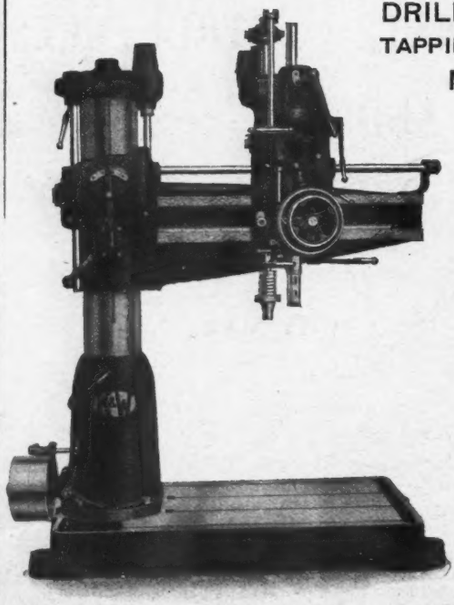
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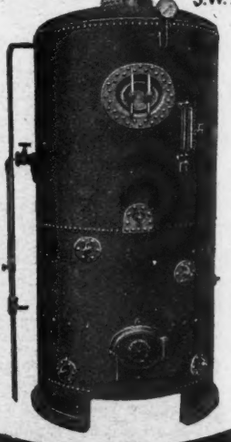
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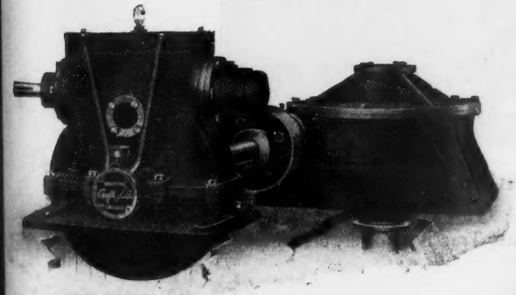

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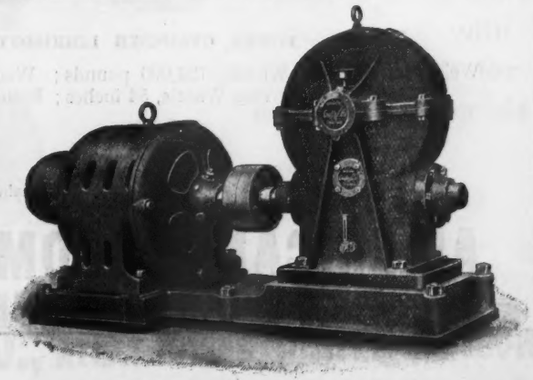

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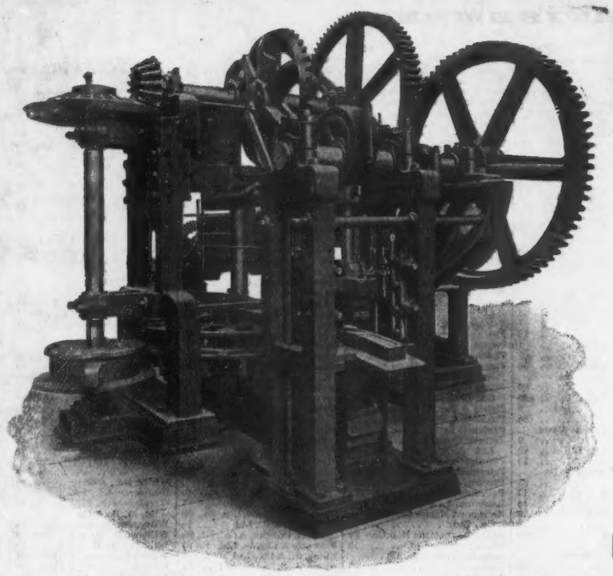

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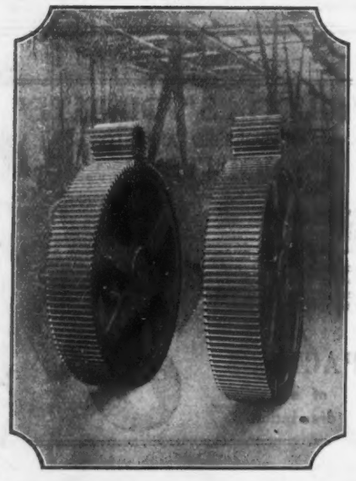

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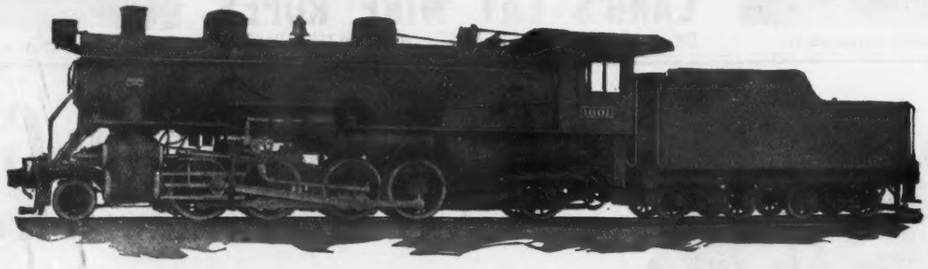

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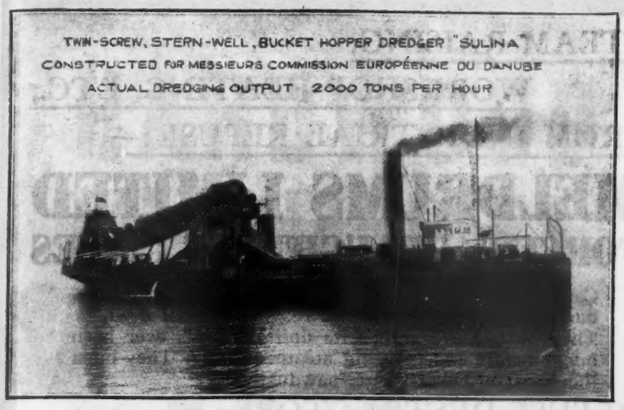
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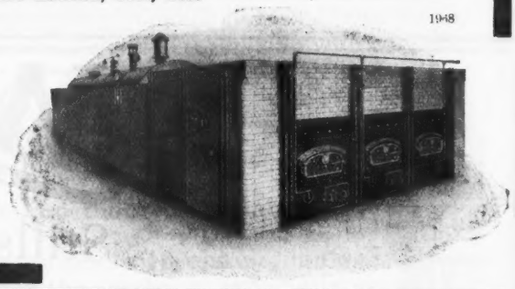

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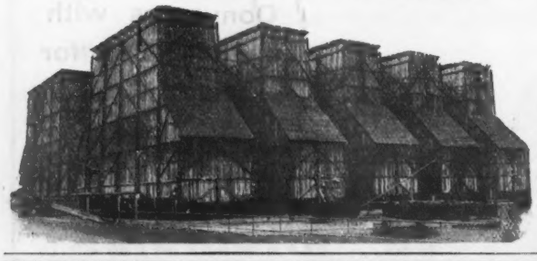

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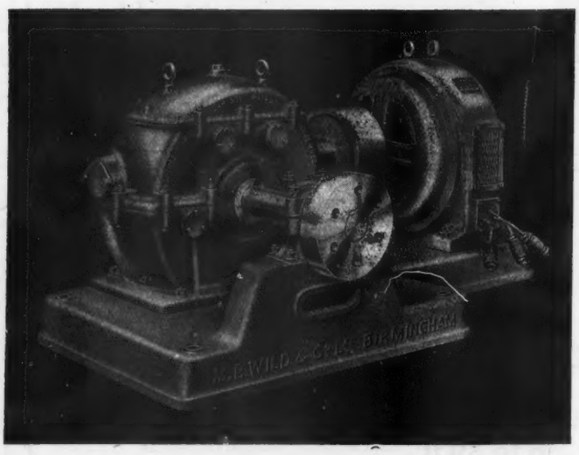

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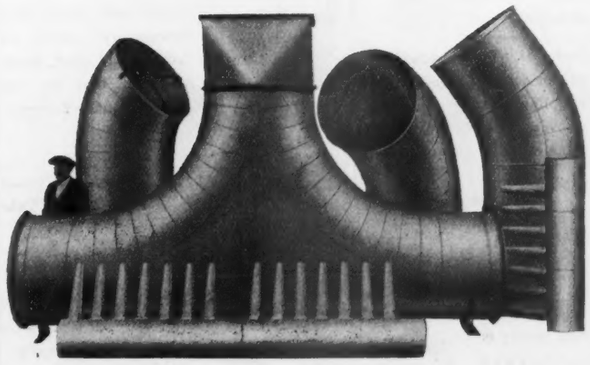

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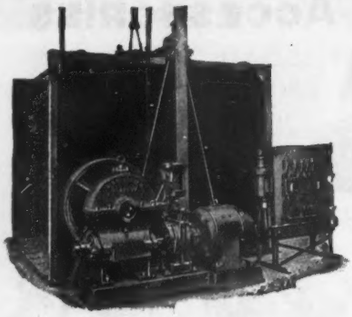

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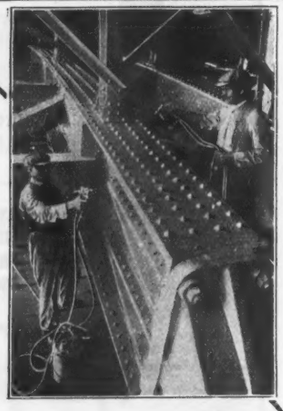

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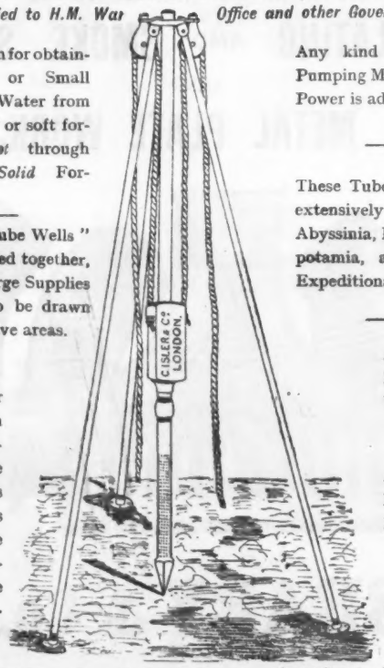

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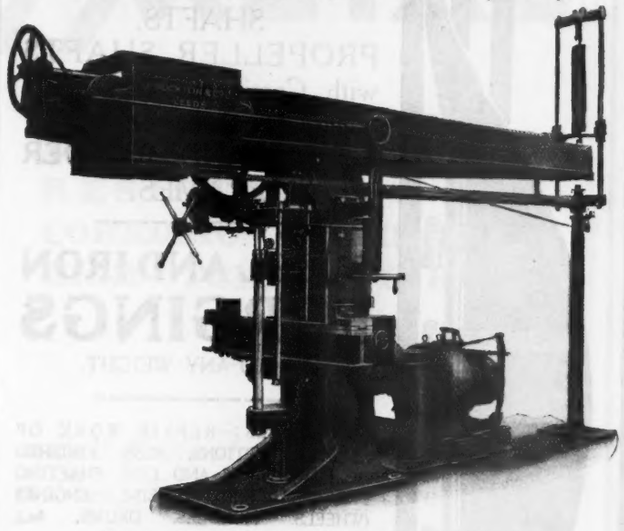

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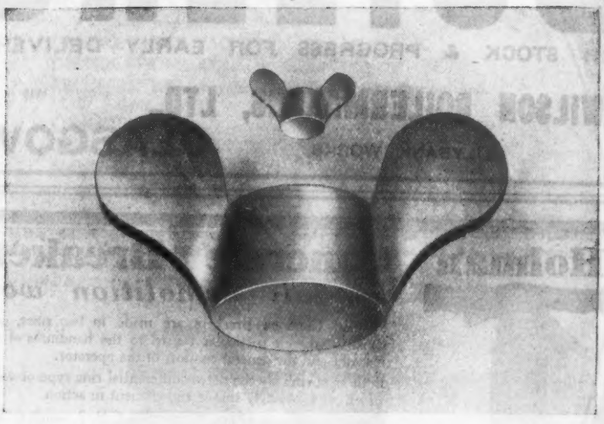

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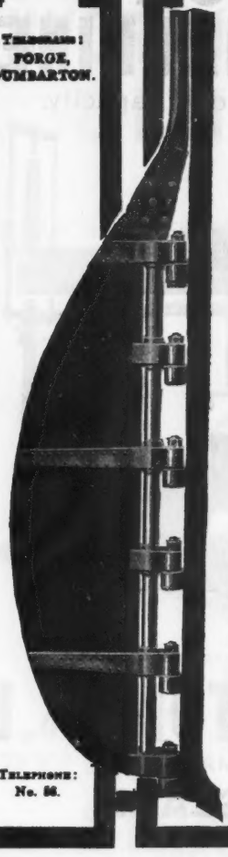

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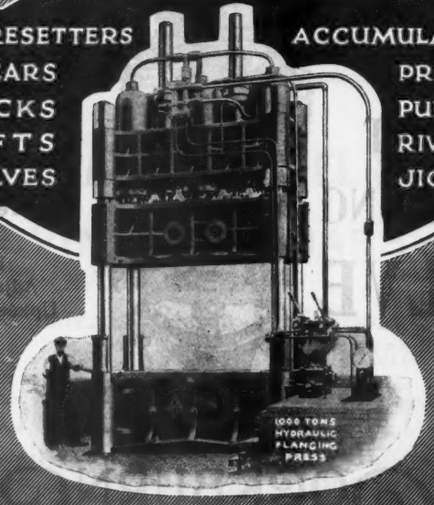

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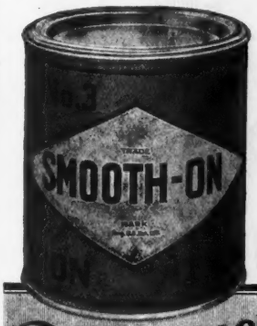

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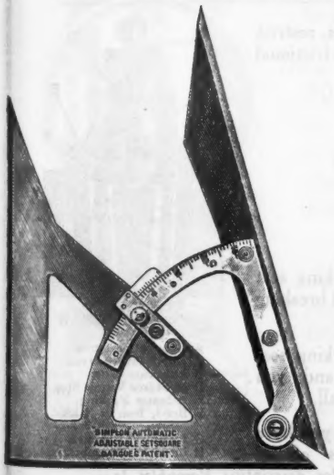

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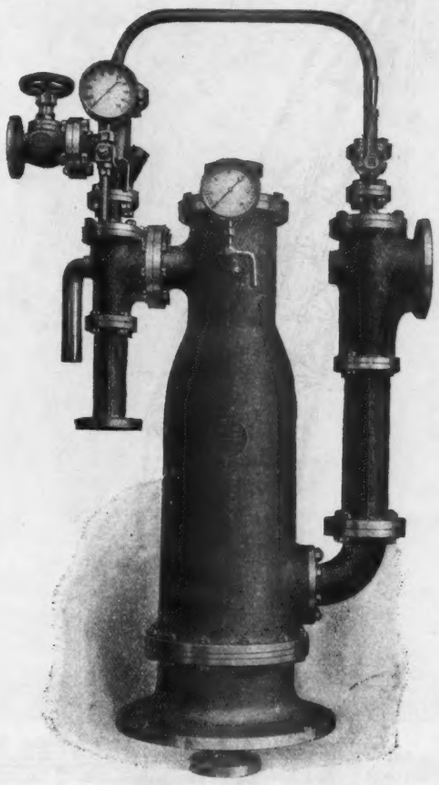

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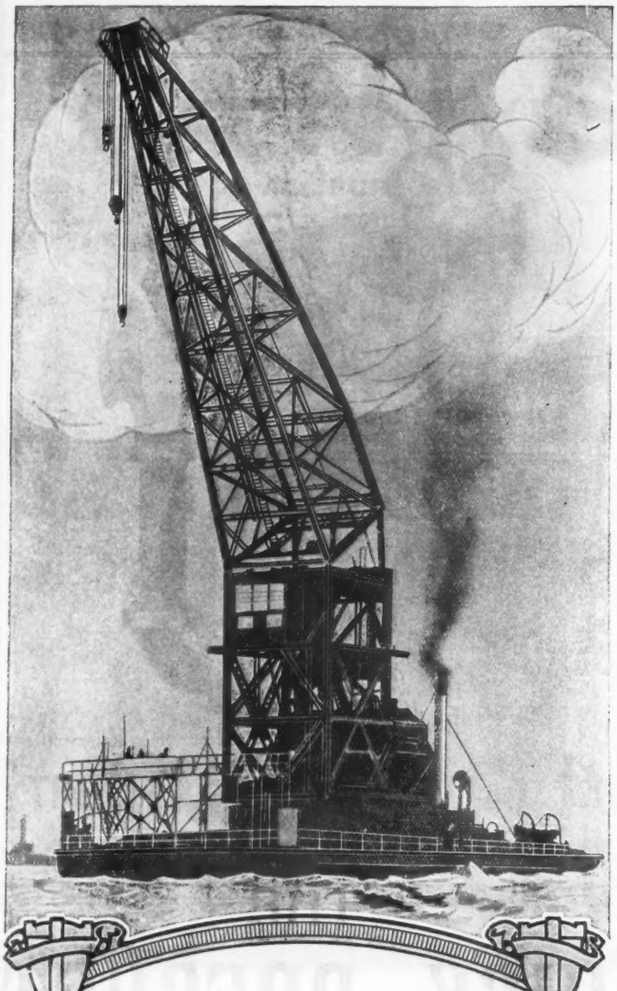

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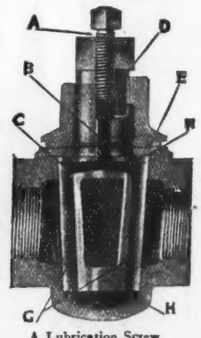

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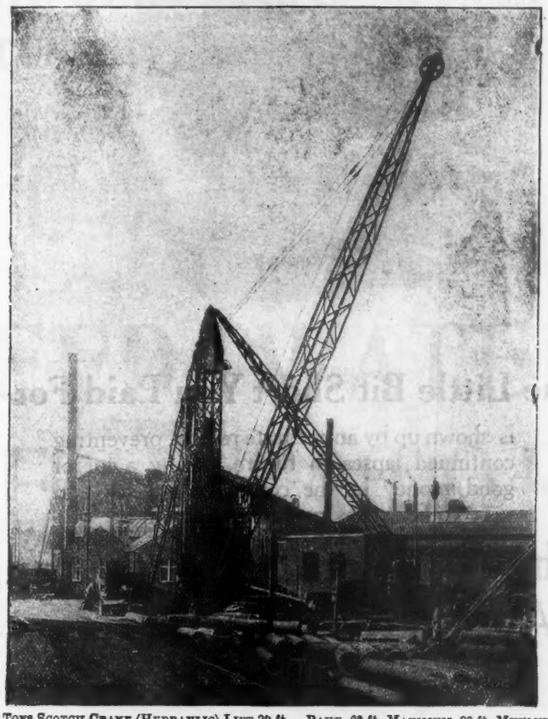

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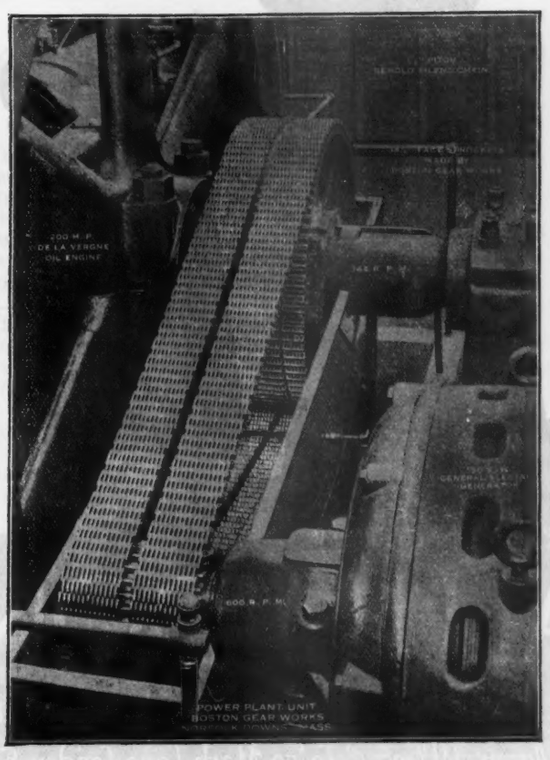

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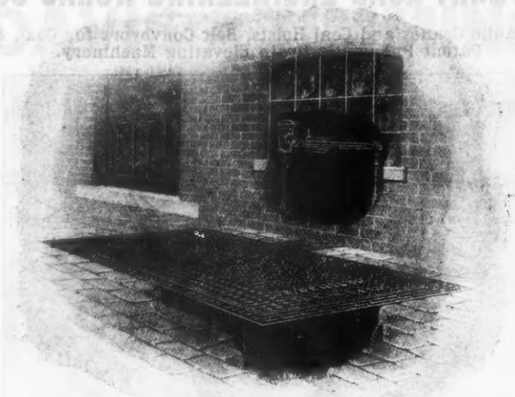

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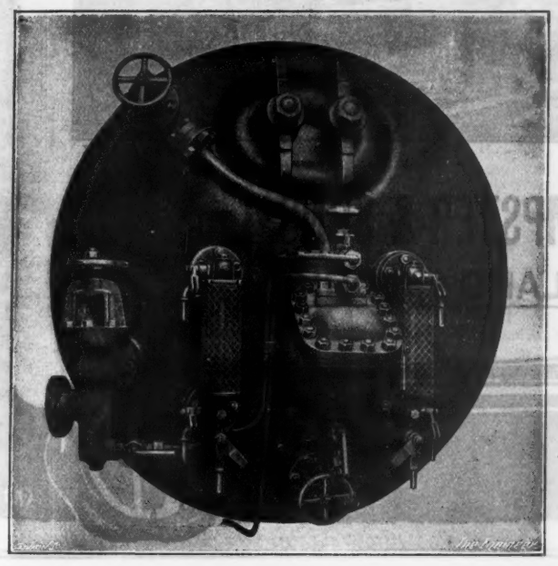

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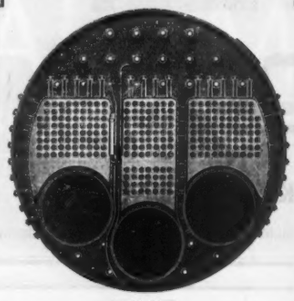

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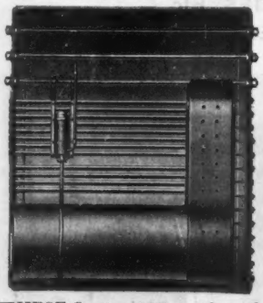

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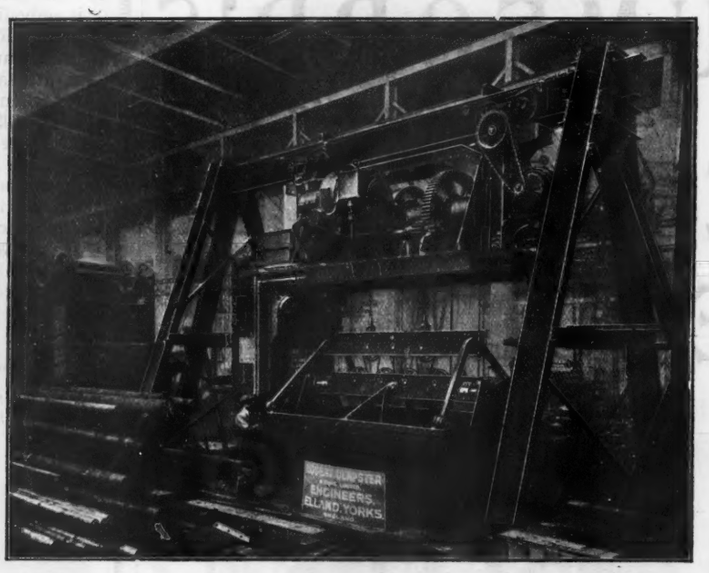

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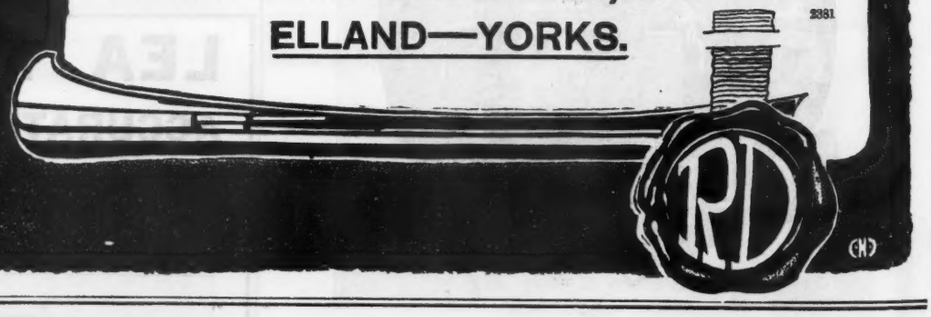

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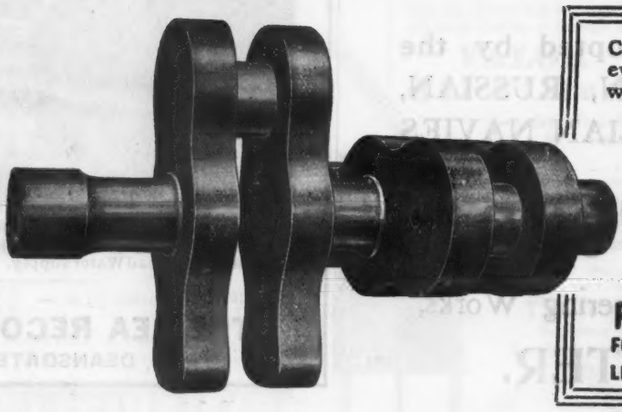

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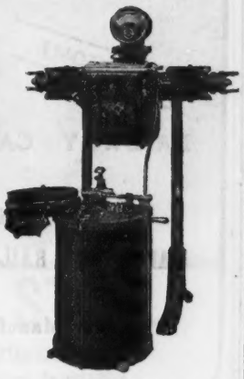

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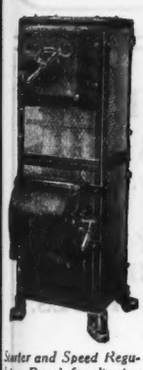

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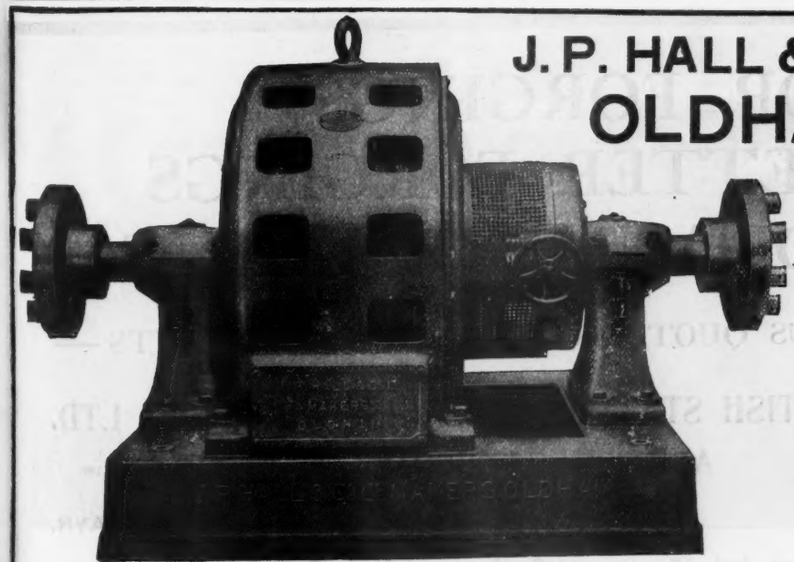

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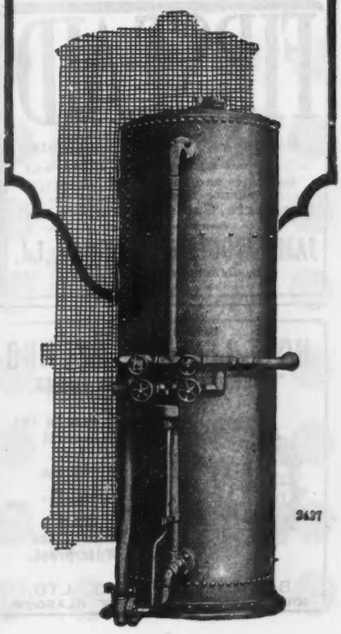

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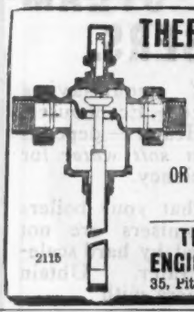

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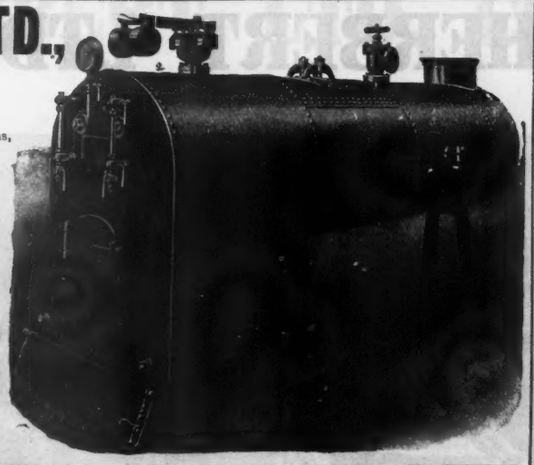

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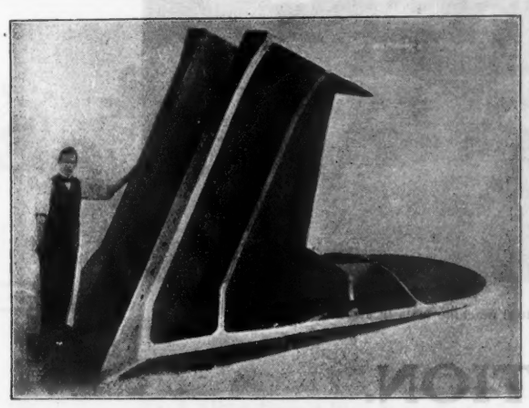

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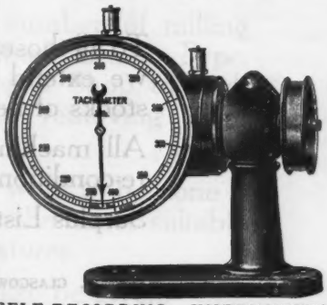

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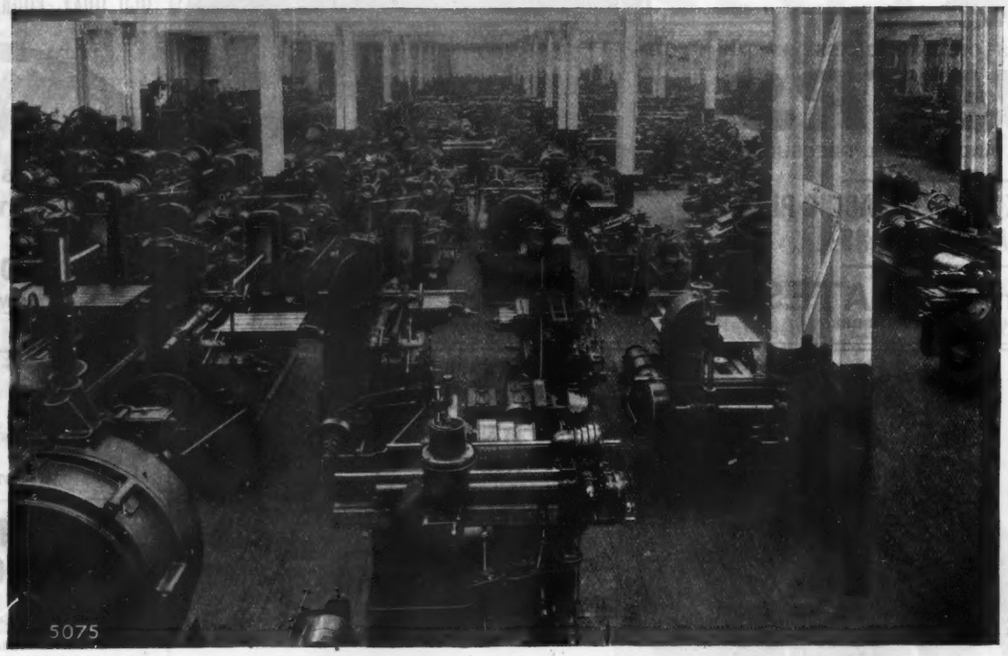

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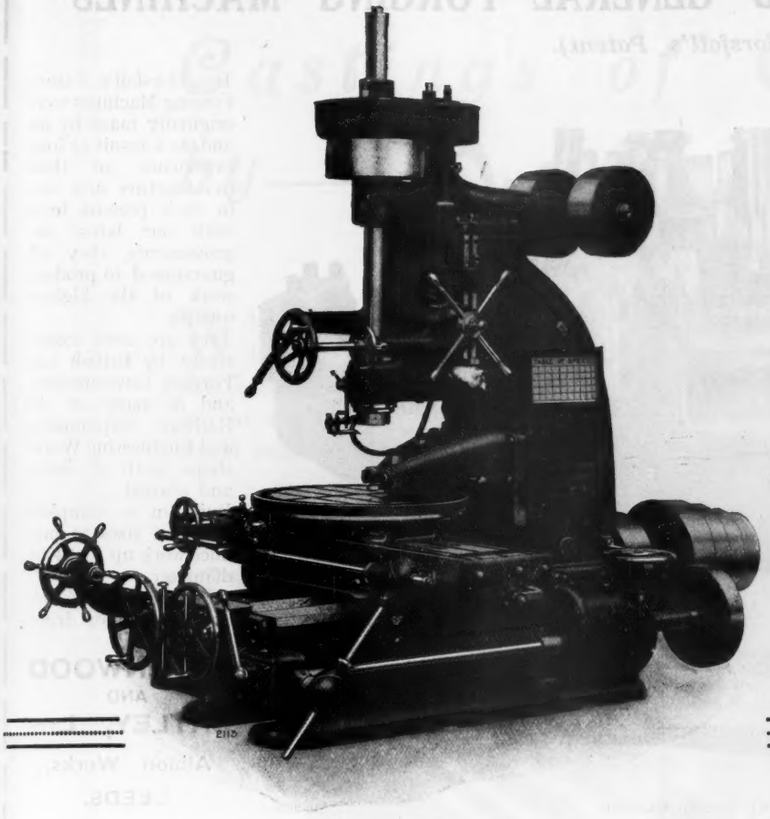

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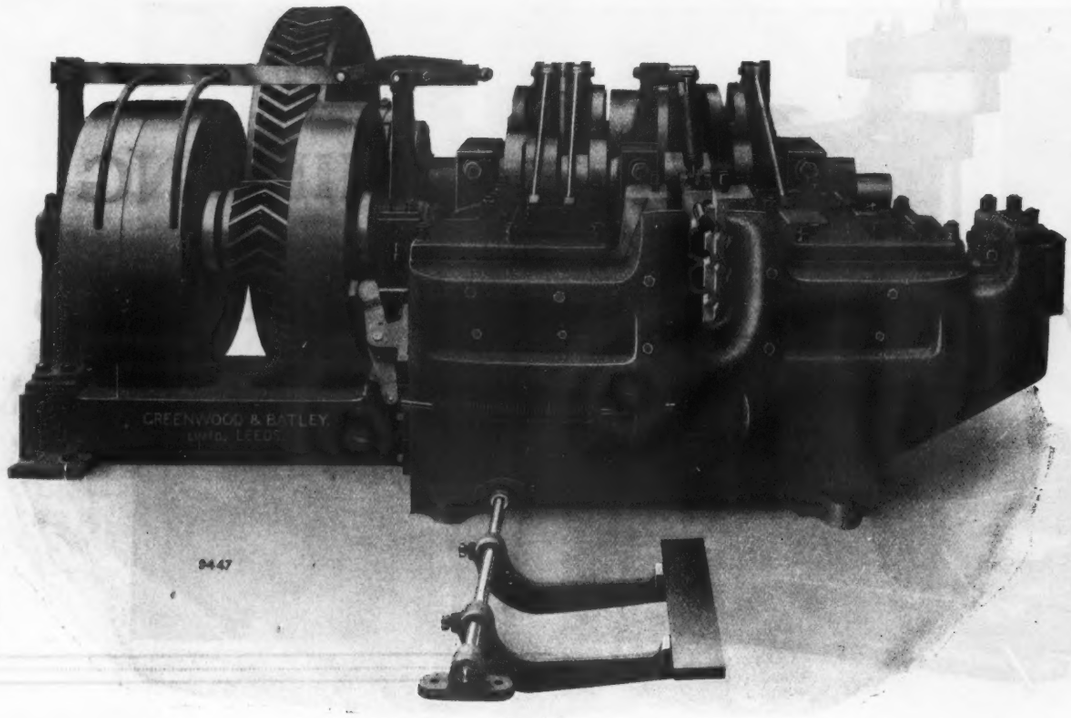

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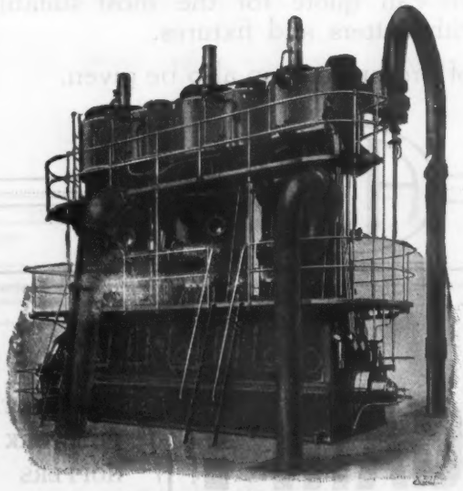

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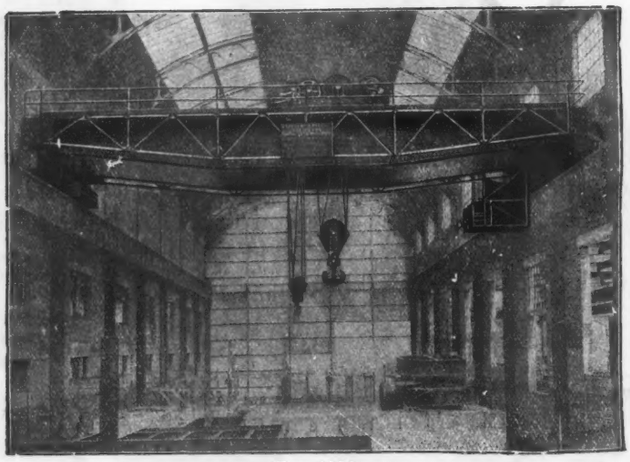

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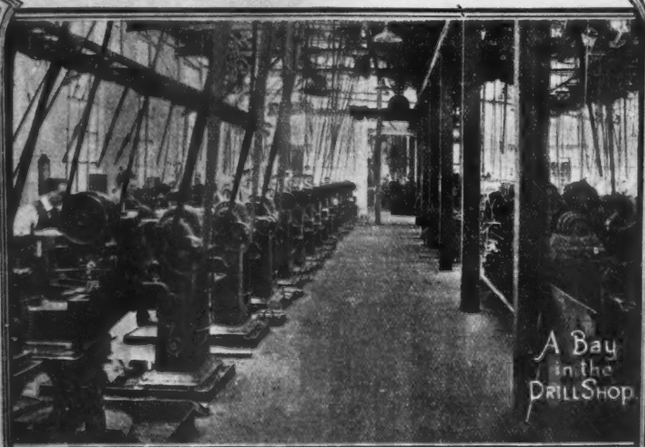

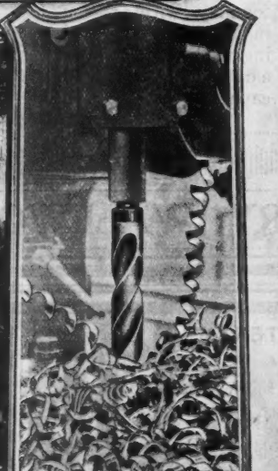

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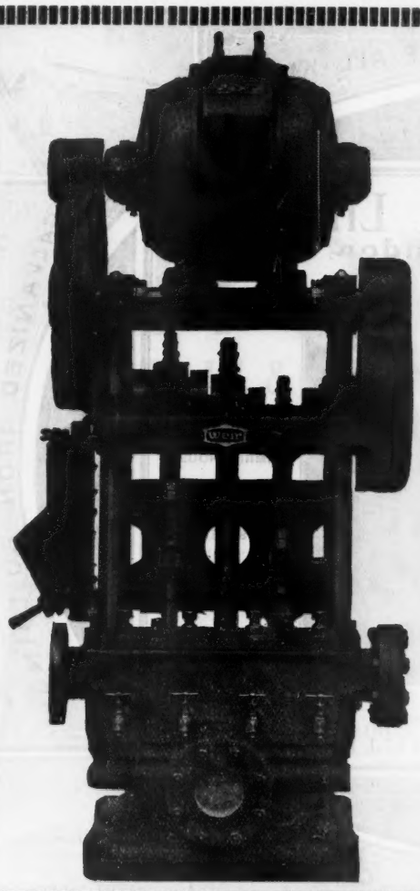

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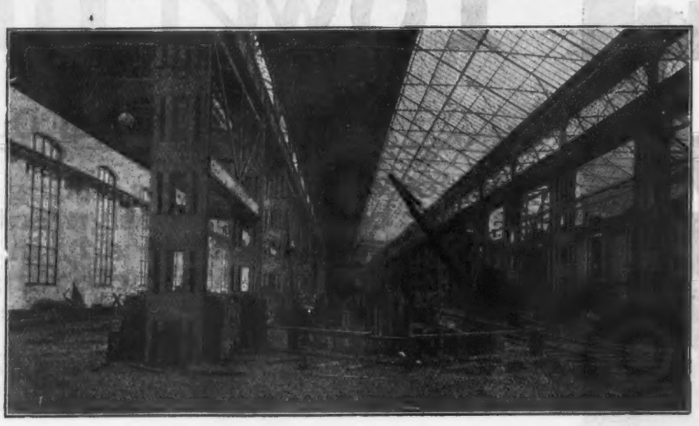

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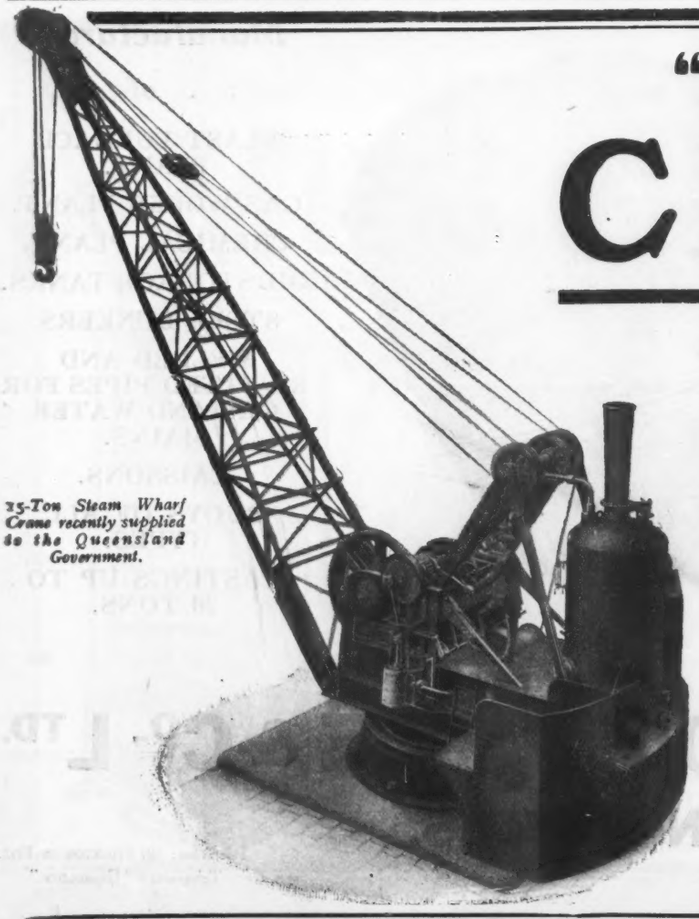

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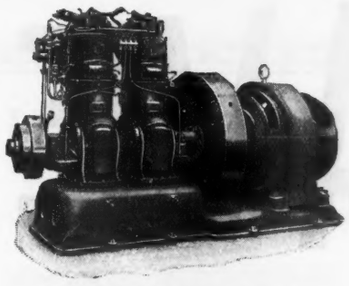
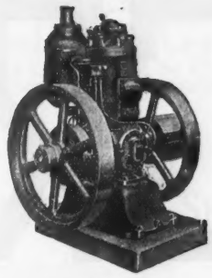


Electric Generating Plant.



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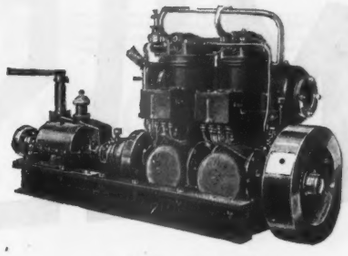

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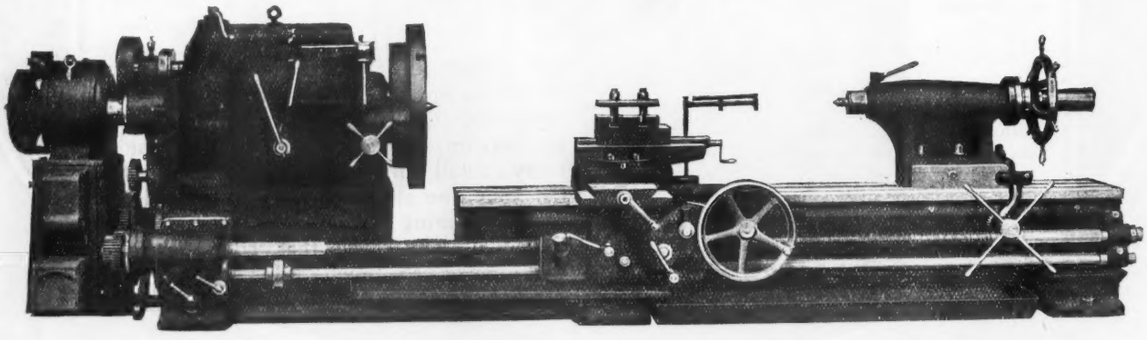

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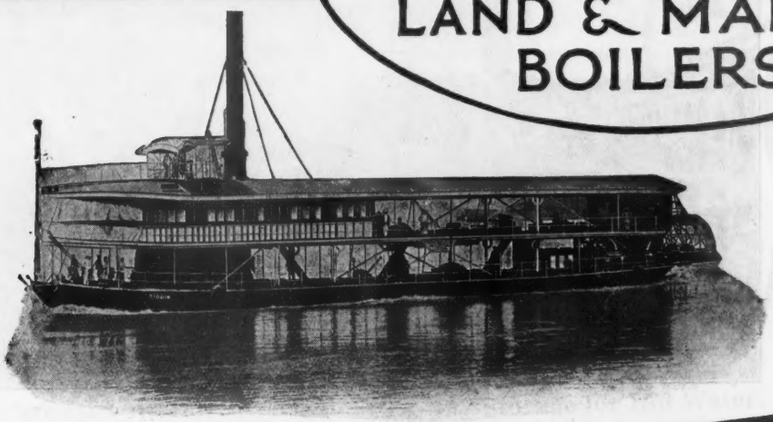

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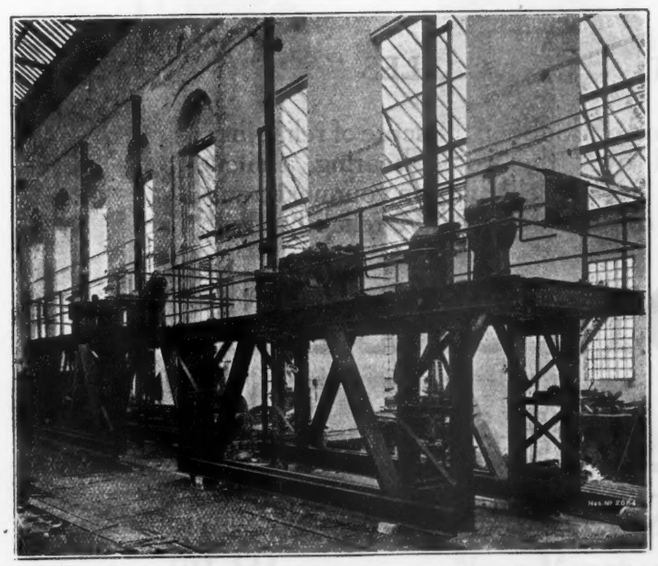

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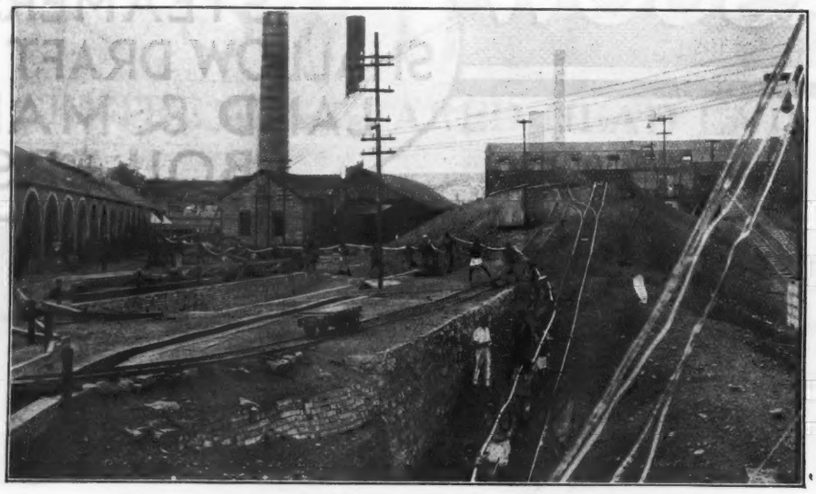

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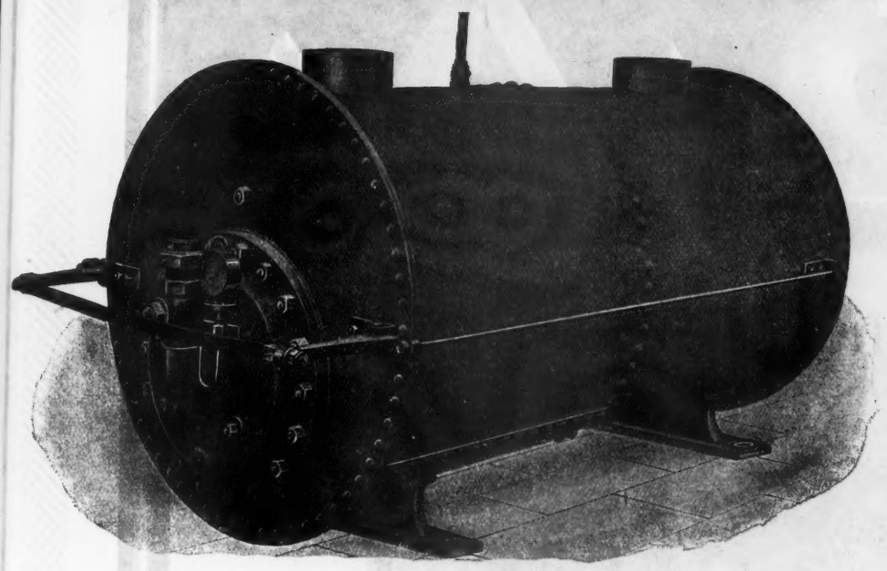

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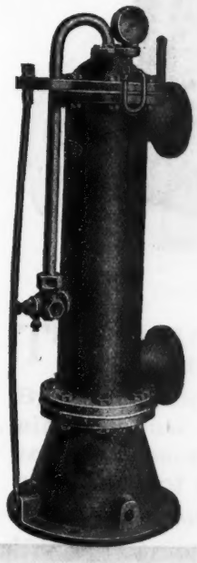
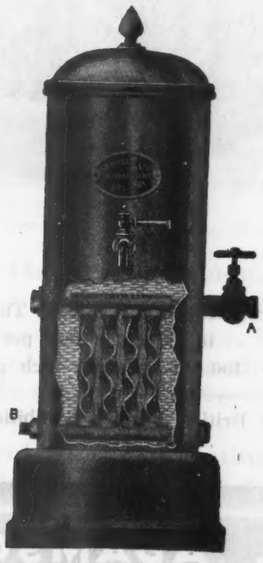
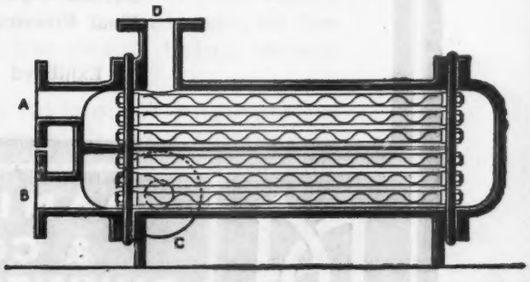


Row's Patent CALORIFIER Standard Pattern.



Row's Patent Steam KETTLE.



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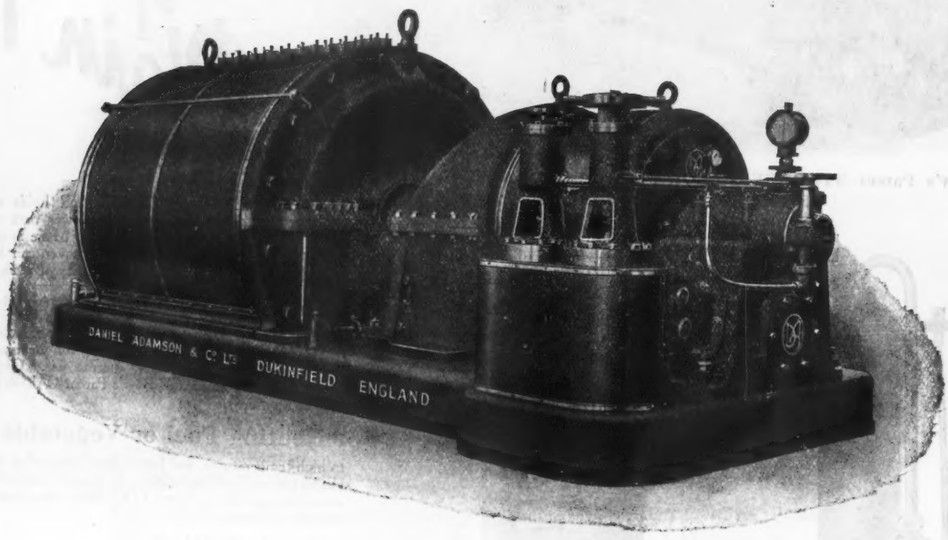

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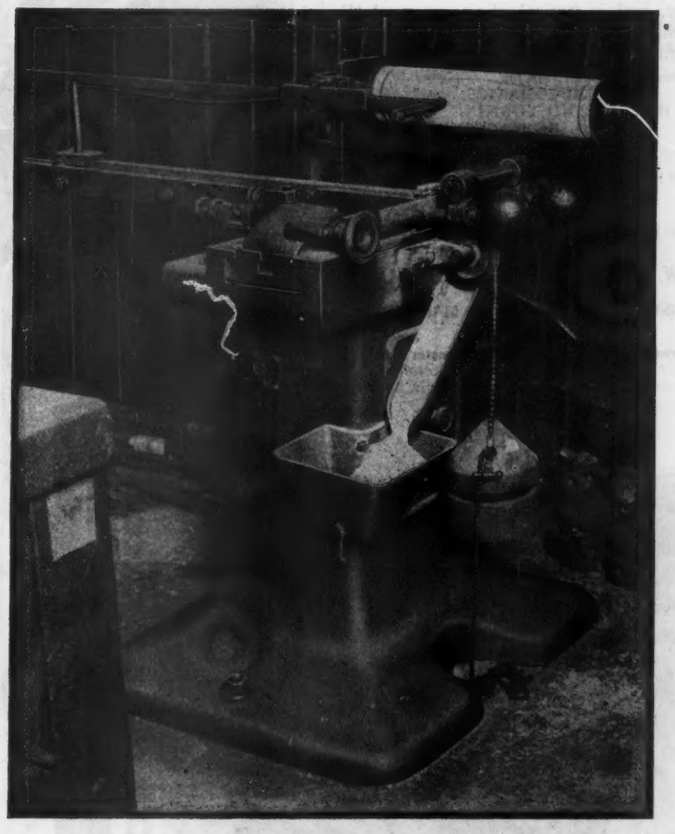

The illustration shows one of the File Testing Machines in use in Firth's File Factory.

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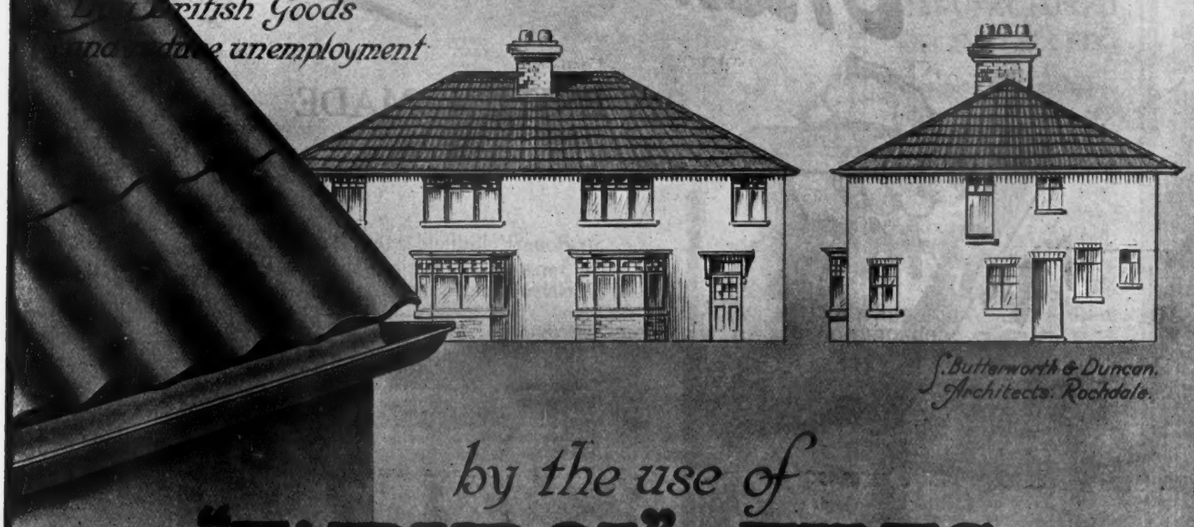

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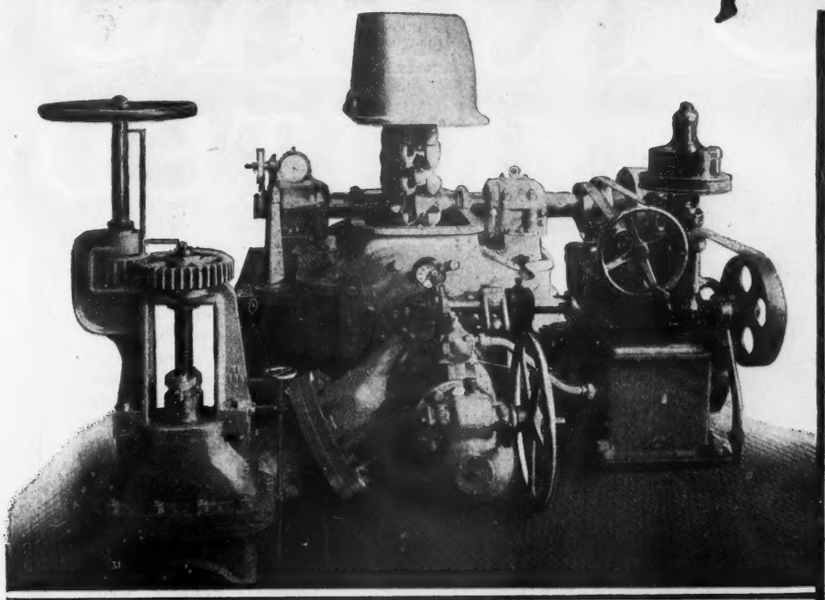

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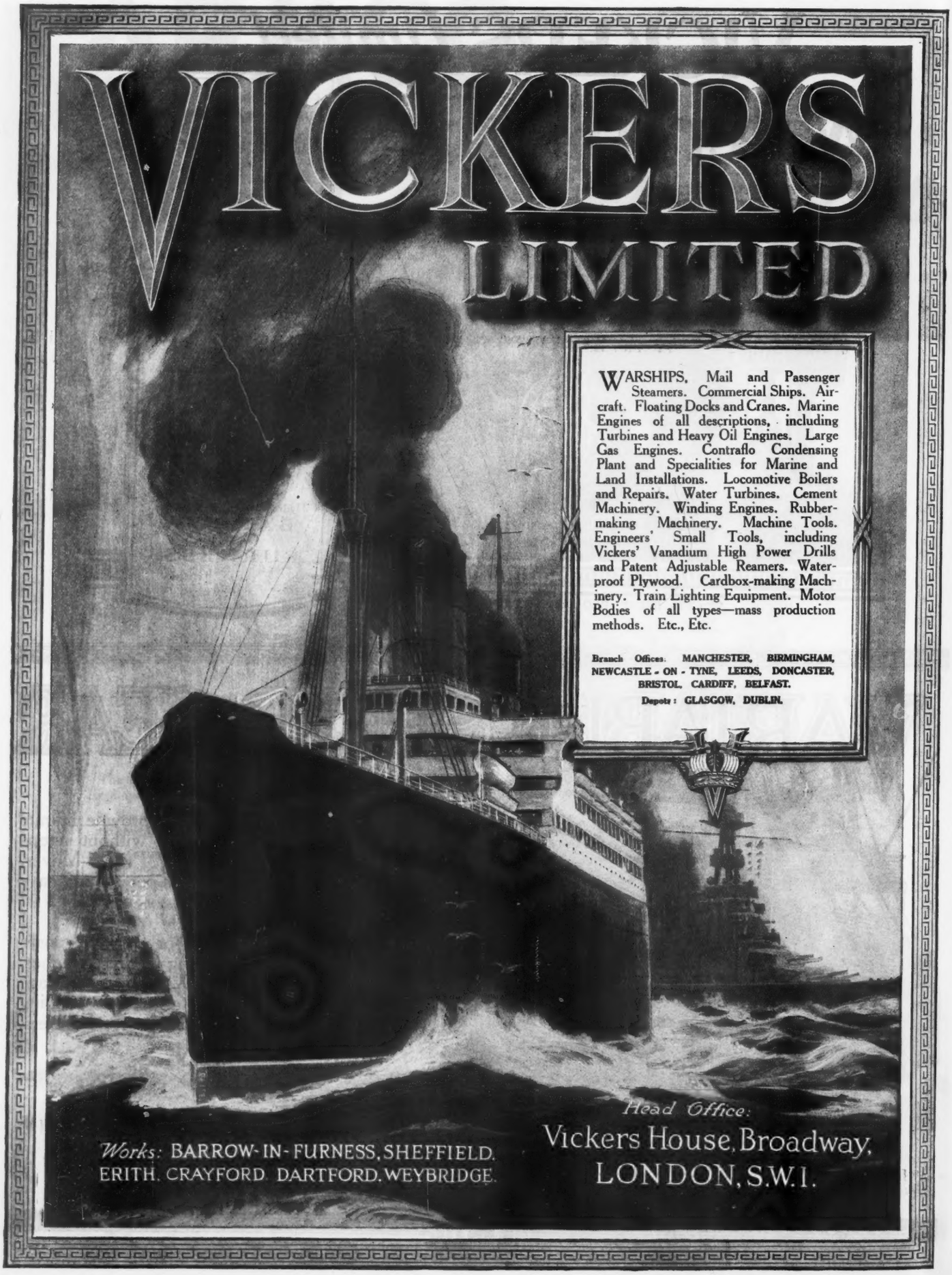
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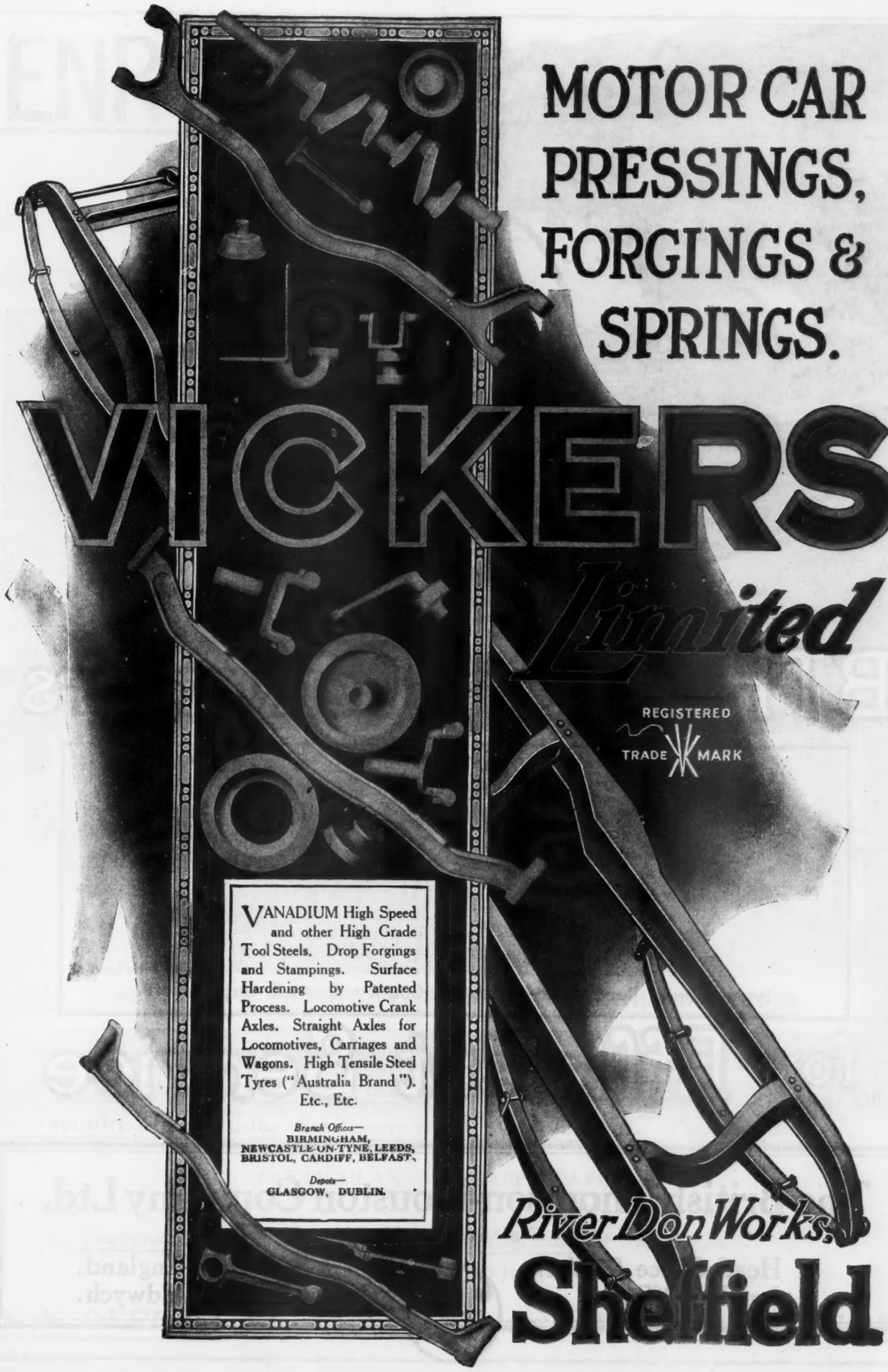

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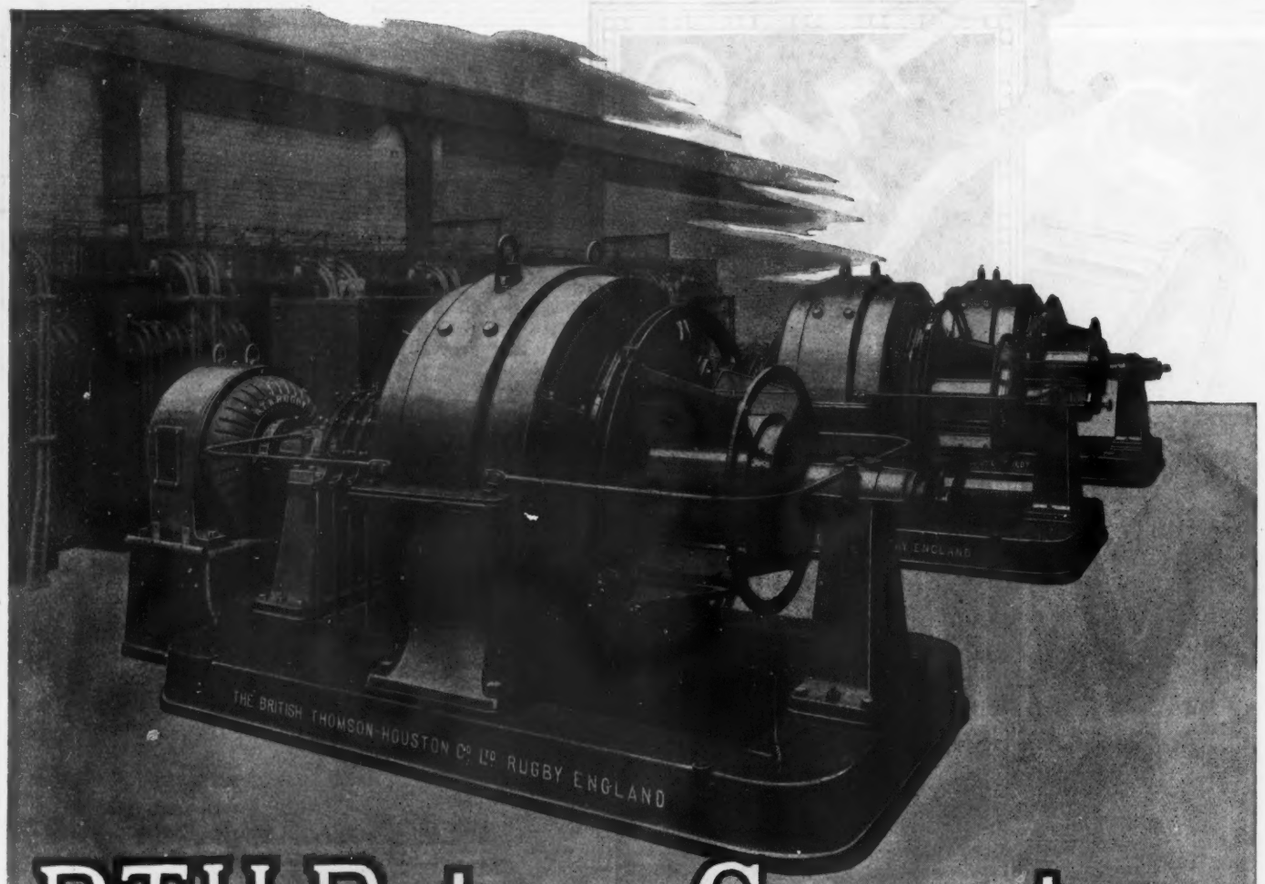

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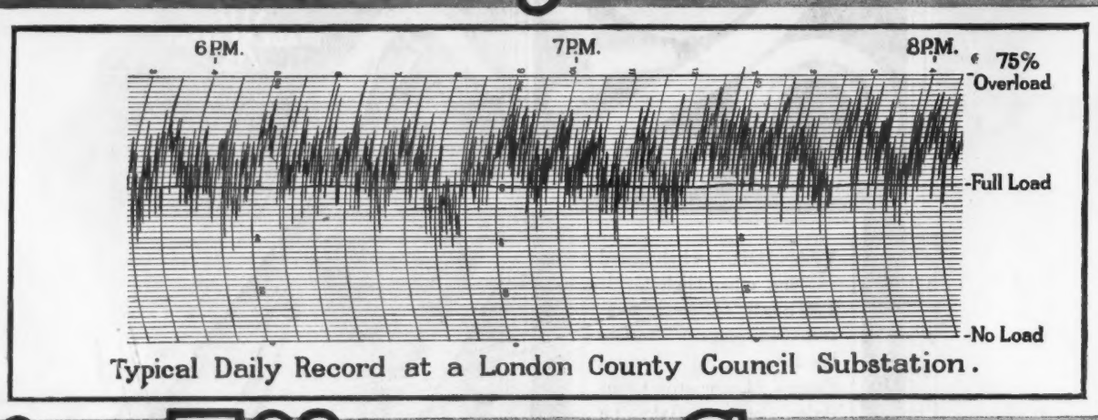

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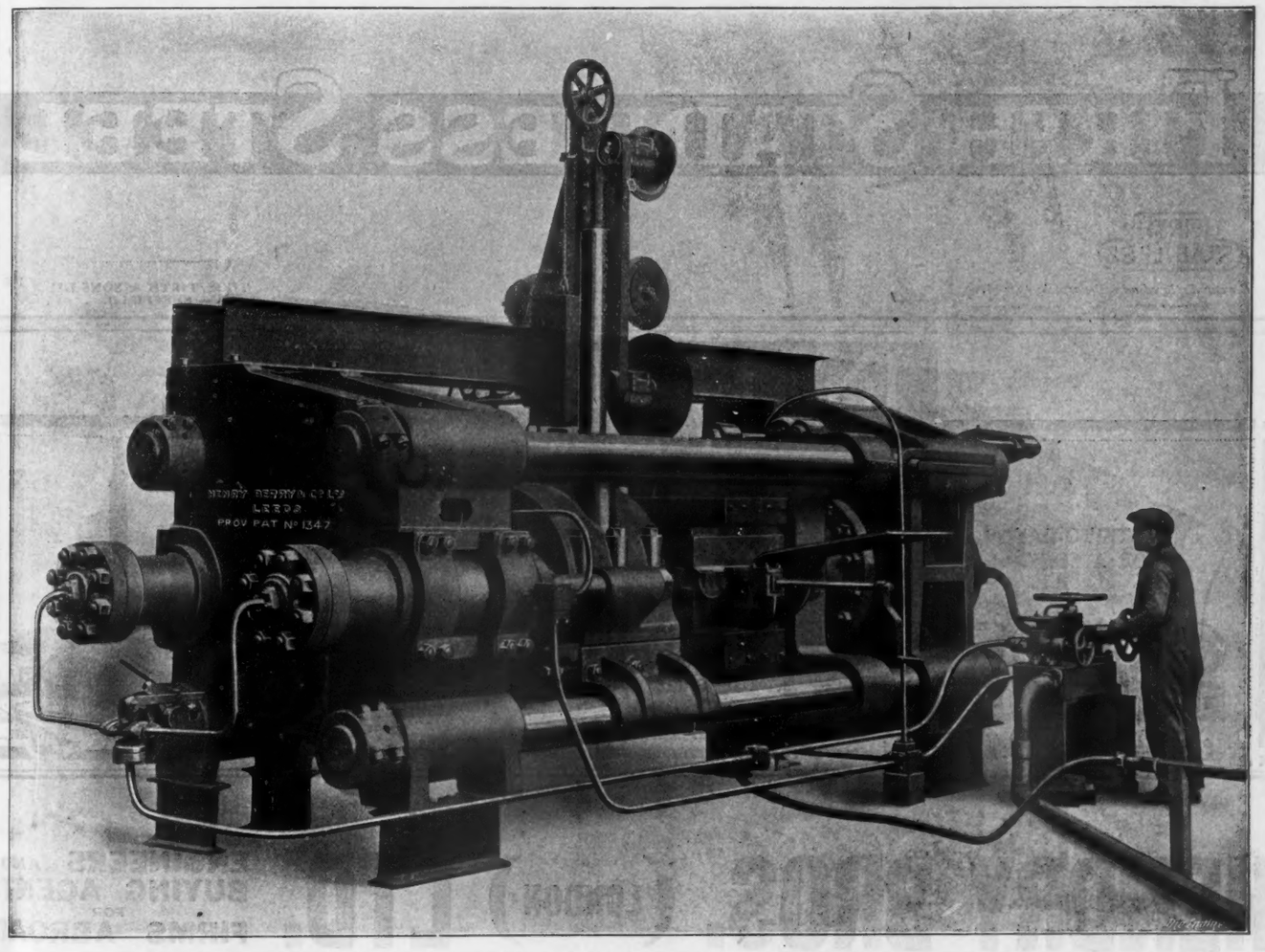

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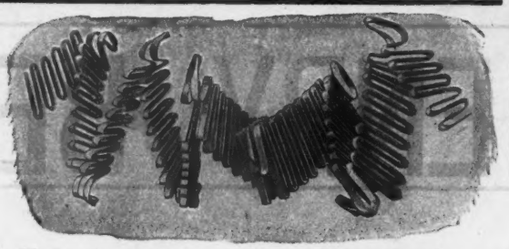

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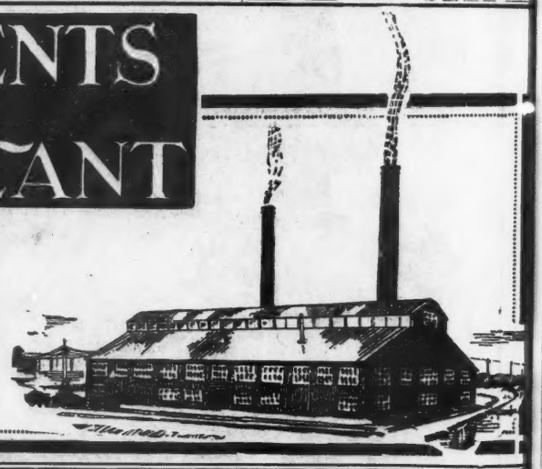

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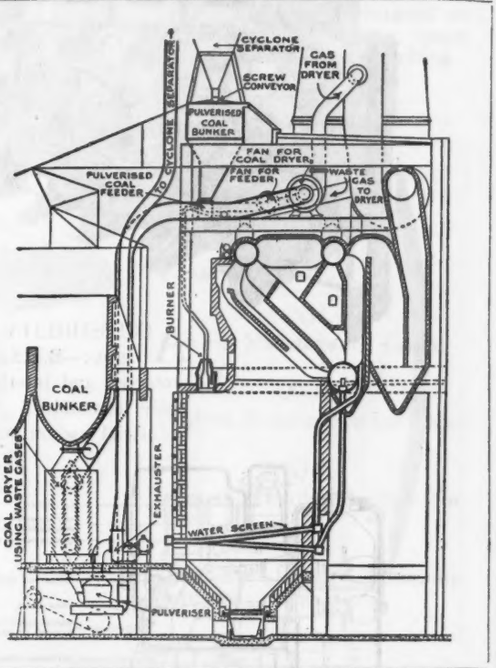

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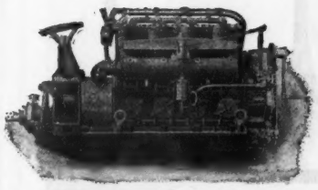

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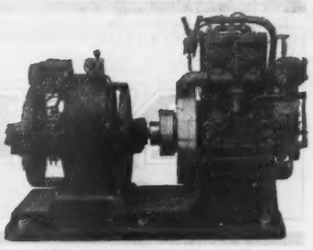

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ACCESSIBLE IRONCLAD
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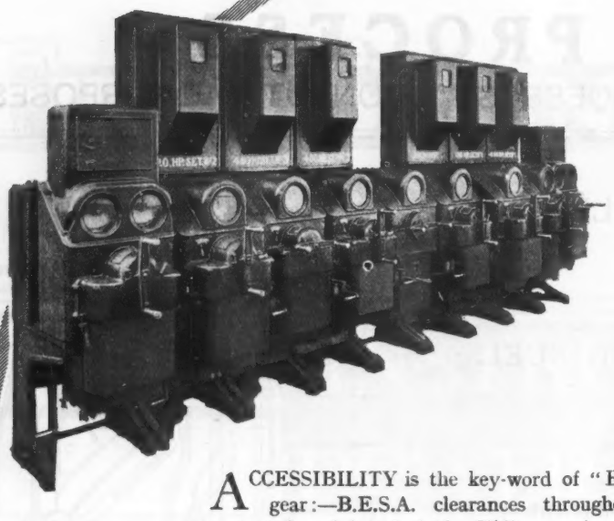

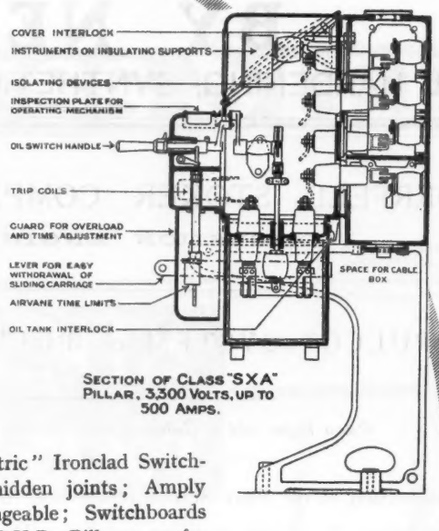

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ACCESSIBILITY is the key-word of "English Electric" Ironclad Switchgear:—B.E.S.A. clearances throughout; No hidden joints; Amply protected and interlocked; Sliding carriages interchangeable; Switchboards easily assembled, Small floor space. The Class S.X.D. Pillars are for Industrial use on small systems.

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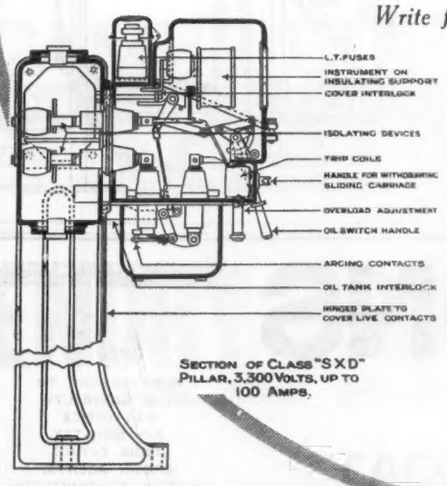
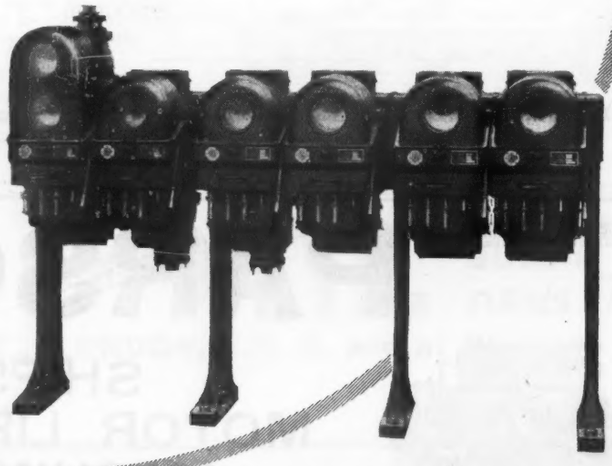


SECTION OF CLASS "SXD" PILLAR, 3,300 VOLTS, UP TO 100 AMPS.



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IF you are intent on obtaining the maximum results from a water-tube Boiler which costs the least to run and the least to maintain, read the following fifteen points about the Spencer-Hopwood Vertical Boiler:

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Costs no more than other Boilers of the same output.

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Raises steam from cold in HALF AN HOUR day after day without any injurious effects.

III.
Has no awkward excrescences.

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Occupies less floor space than any other boiler for the same output.

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VI.
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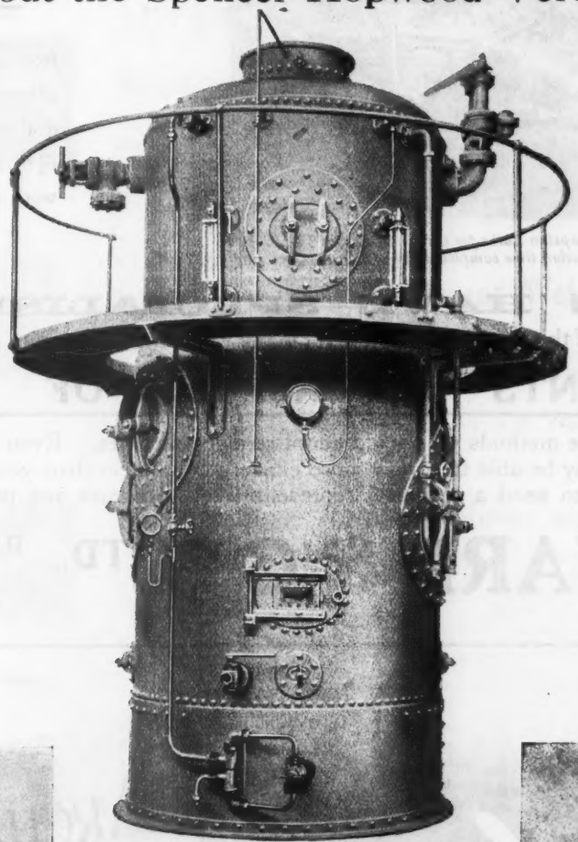
The tubes are immediately accessible for renewal, inspection, or internal cleaning, by removing the easily-handled mandoors at the side.



VIII.
The tubes can be cleansed on the fire side with a lance while the boiler is working.

IX.
Most Portable.

X.
33% Overload Capacity.

XI.
Longest Life.

XII.
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XIII.
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Only five feet of Chimney required.

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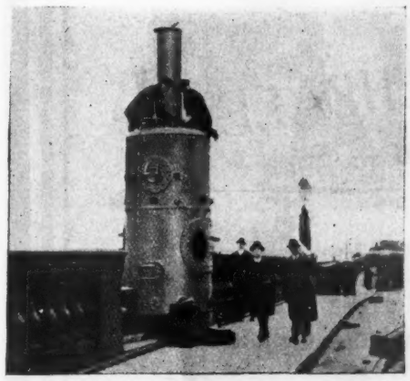

No. 16. Standard Pattern "Spencer-Hopwood" working on Waterloo Bridge in connection with repairs, May, 1924.

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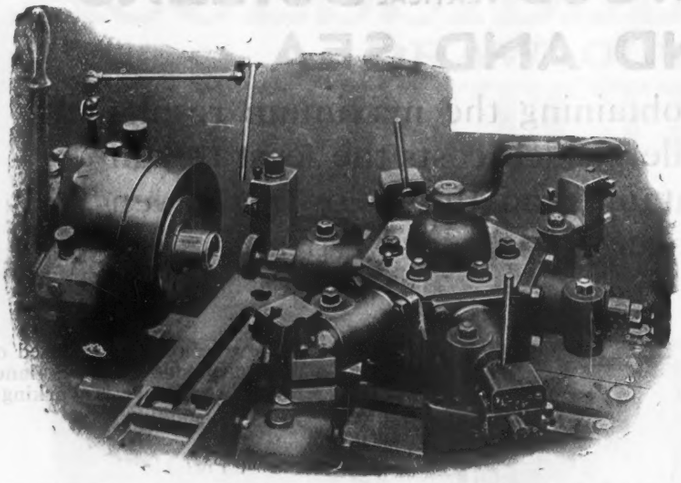

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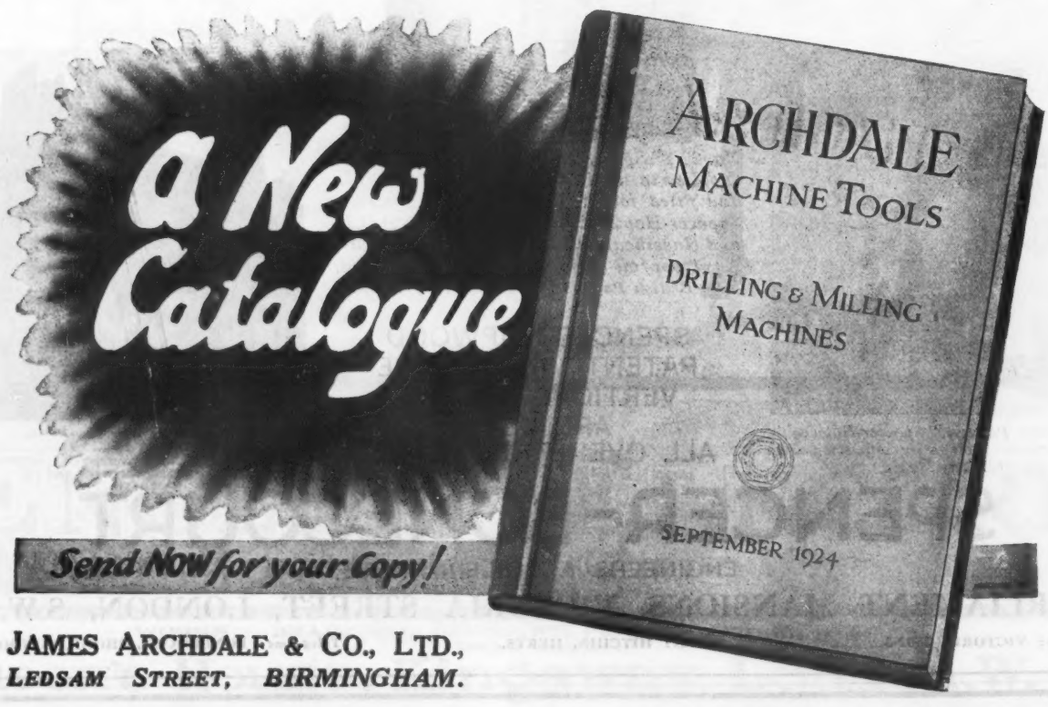

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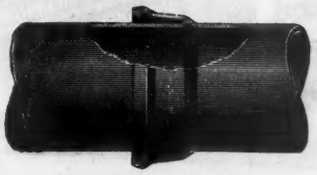
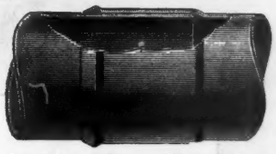


Patent Inserted Joint.
(Patent No. 3189/11.)

Stewarts' Patent Inserted Joint

The shape of the socket on this joint precludes the possibility of the lead being blown out by ordinary pressure, and enables the thinnest practicable caulking tool to be employed. The doubling of the metal at the rim of the socket gives it great strength where the stress due to caulking is most severe.

For full particulars see Section W. of Catalogue.

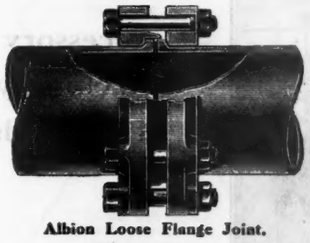


Longsleeve Patent Welded Joint.
(Patent No. 6172/12.)

Stewarts' Longsleeve Patent Welded Joint

This joint is strongly recommended for High Pressure Gas, being specially designed to facilitate the welding of pipes into a continuous main by means of the oxy-acetylene or oxy-hydrogen blow pipe. The joint can be made without turning the pipes round.

For full particulars send for Section W. Supplement of Catalogue.

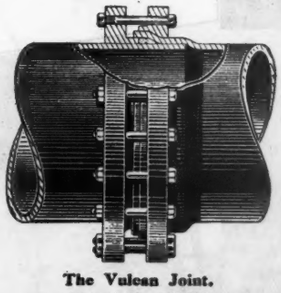


Albion Loose Flange Joint.

Loose Flange Joints for Mining and Contractor's Work

We manufacture these joints in two standard forms, generally known as Stewarts' No. 1 Loose Flange Joint and Albion Loose Flange Joint. The former is made by flanging the pipe end, while in the latter, additional strength is obtained by working up the ends of the pipe into collars by special machinery. In both cases the joints are supported by Cast Iron, Cast Steel or Wrought Flanges recessed as shown, to preclude the blowing out of jointing material.

For full particulars send for Section W. of Catalogue.



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(Patent No. 16843.)

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Welded Steel Pipe Lines

Specially recommended for Hydro-Electric Pipe Lines for the highest pressures, and made in diameters up to 6 feet. Other forms of Joints can be supplied according to requirements and nature of pipe work. When sending enquiries, the total head and full particulars of water supply should be given, if possible, accompanied by a profile of the ground over which the Pipe Line will be laid.

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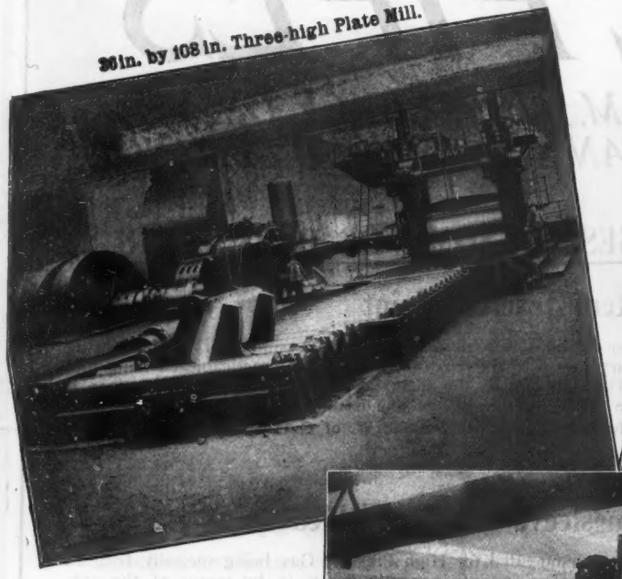

36 in. by 108 in. Three-high Plate Mill.

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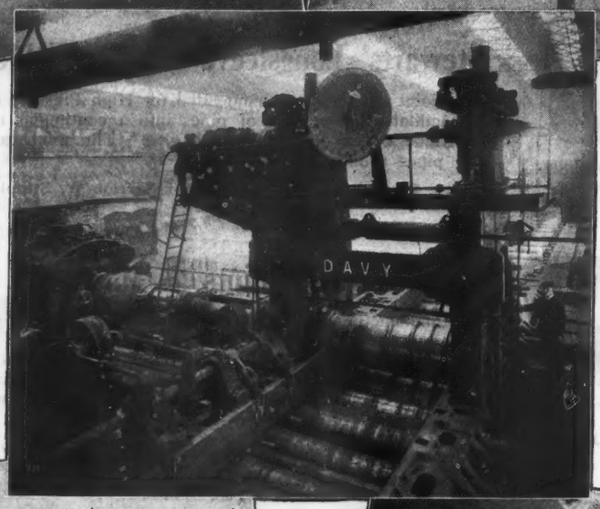

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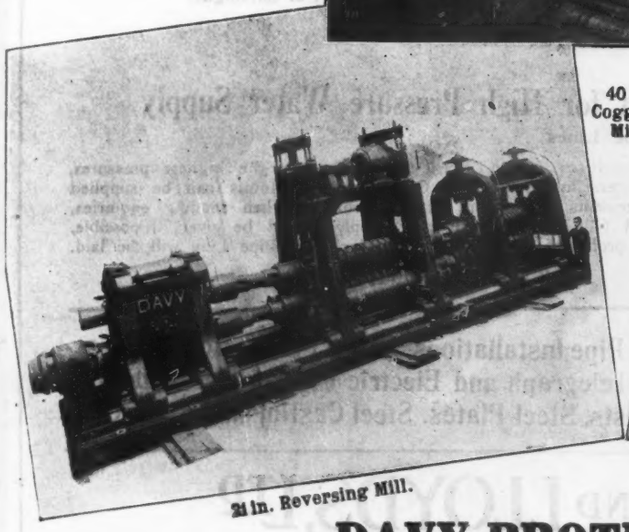

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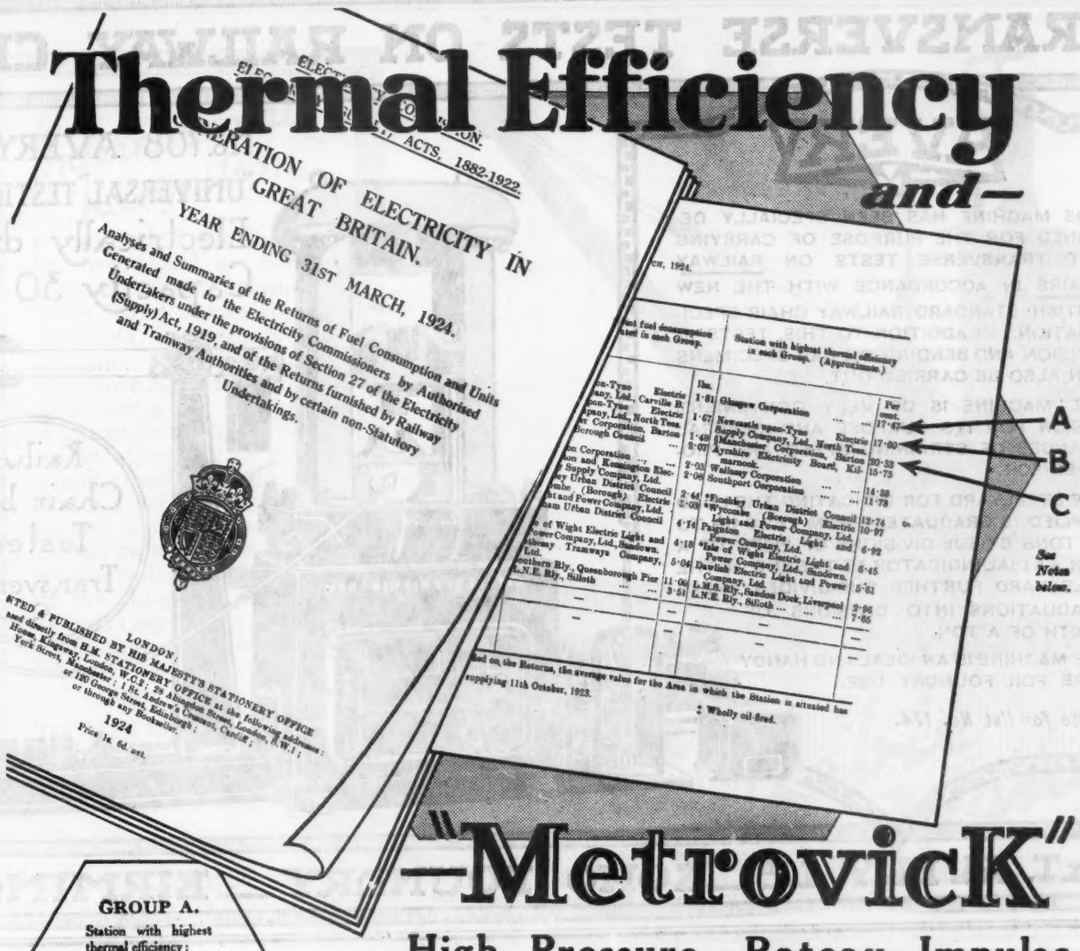
ELECTRICITY ACTS, 1882-1922.
GENERATION OF ELECTRICITY IN GREAT BRITAIN.
YEAR ENDING 31ST MARCH, 1924.
Analyses and Summaries of the Returns of Fuel Consumption and Units Generated made to the Electricity Commissioners by Authorised Undertakers under the provisions of Section 27 of the Electricity (Supply) Act, 1919, and of the Returns furnished by Railway and Tramway Authorities and by certain non-Statutory Undertakings.
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Price 1s. 6d. net.
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Ayrshire Electricity Board, Kilmarnock.
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Isle of Wight Electric Light and Power Company, Ltd., Sandown.
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A
B
C
See Notes below.
* Wholly oil-fired.

—Metrovick"

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Steam Turbines.

THE Analyses and Summaries of the Electricity Commission for the year ending 31st March, 1924, reproduced above, gives particulars of the station with the highest Thermal Efficiency in each group. Glasgow, North Tees and Barton, head the list in their respective groups.

Each of these three stations is equipped with "METROVICK" RATEAU-IMPULSE STEAM TURBINES, those at Glasgow taking over 60% of the load, and those at NEWCASTLE (NORTH TEES) and at MANCHESTER (BARTON) taking the entire load of their respective stations.

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Equipped with two "METROVICK" Steam Turbines, each 18,750 kW. taking over 60% of the load.

GROUP B.
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GROUP C.
Station with the highest thermal efficiency and lowest fuel consumption:
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Equipped with three "METROVICK" Steam Turbines, each 25,000 kW. taking ALL THE LOAD

GROUP D.
Had BELFAST HARBOUR POWER STATION been included in the Commission's Analyses, its record would have been shown under GROUP D. as the station with the *Lowest Fuel Consumption per unit*, and *Highest Thermal Efficiency* from 1.868 lbs. per unit, and 17.97%, in the group. The 12,500 k.w. "METROVICK" Steam Turbine at present installed takes 89.22% of the load. A duplicate "METROVICK" Set is nearing completion.

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"Bristol Trials" No. G7420/1.

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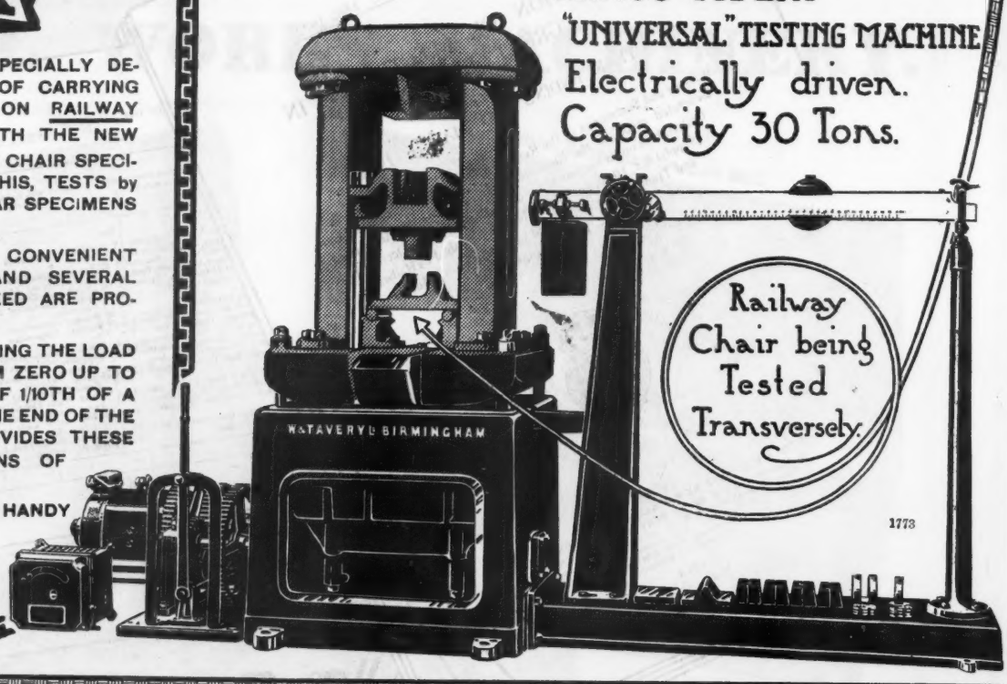

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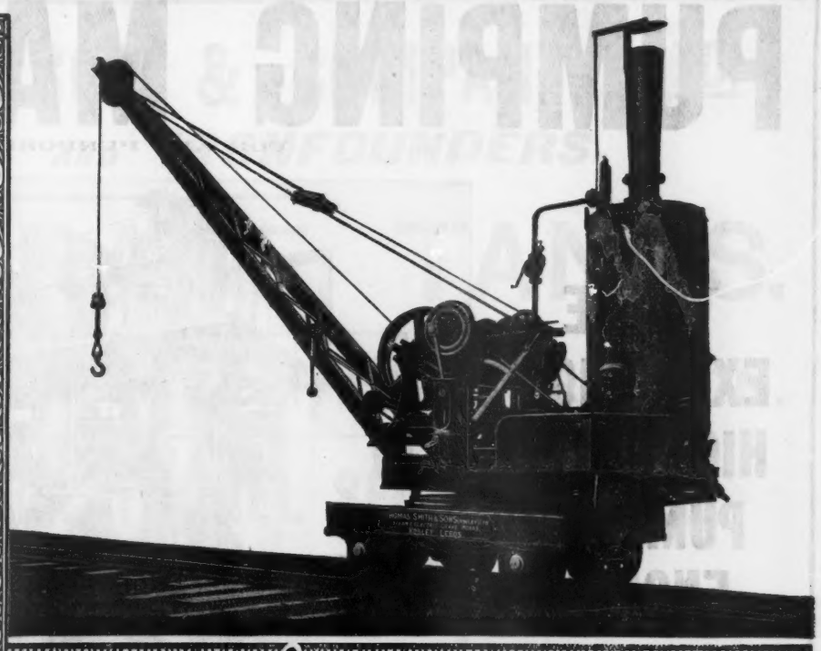

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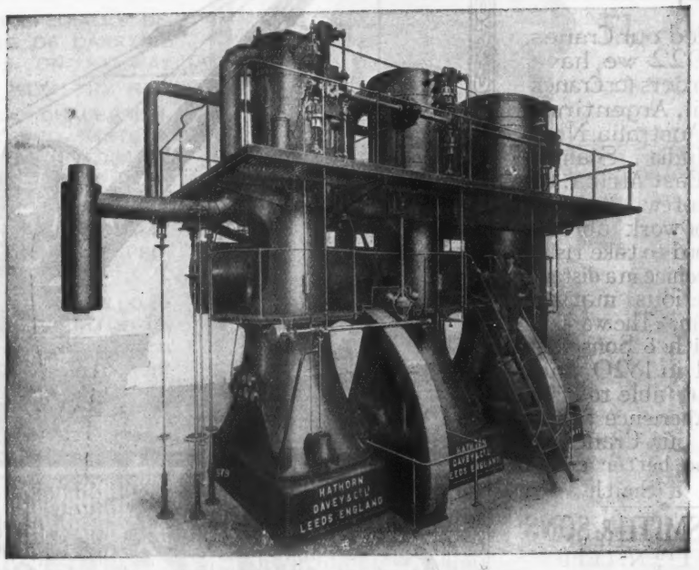

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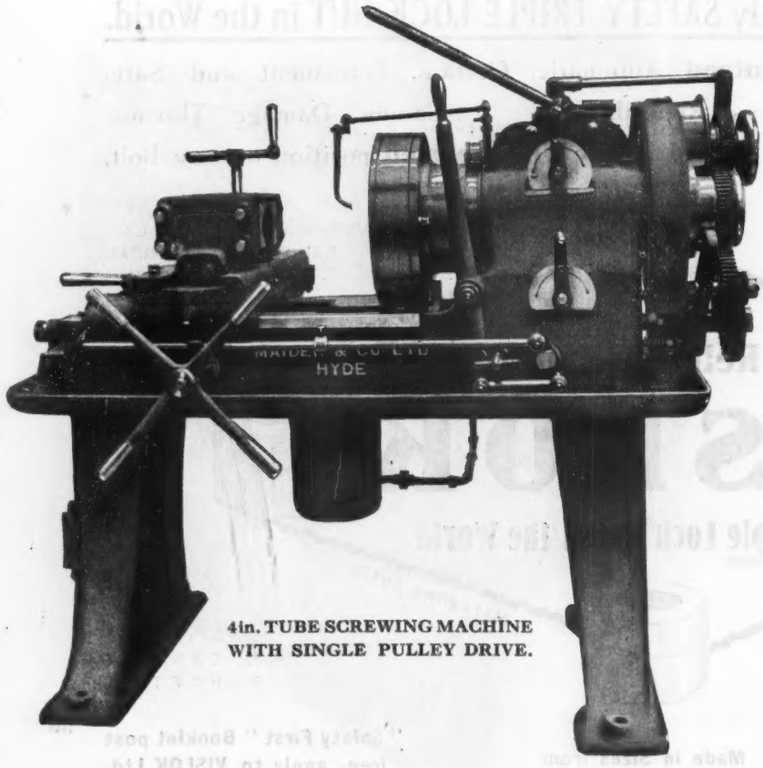

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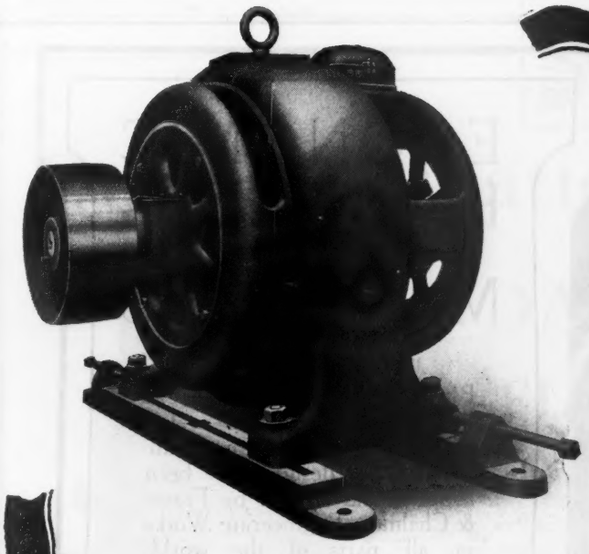

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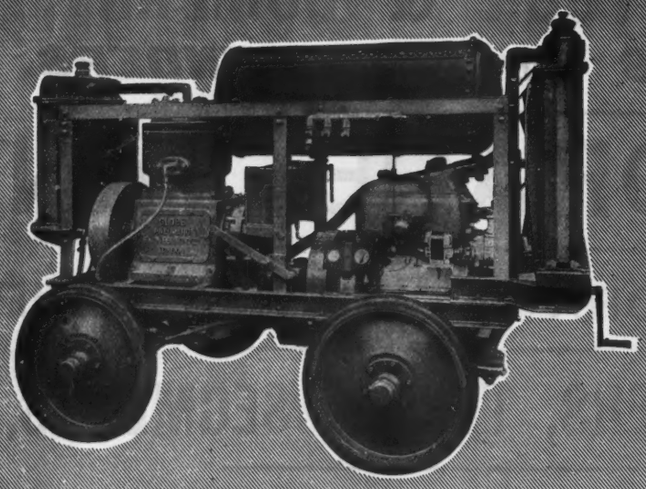

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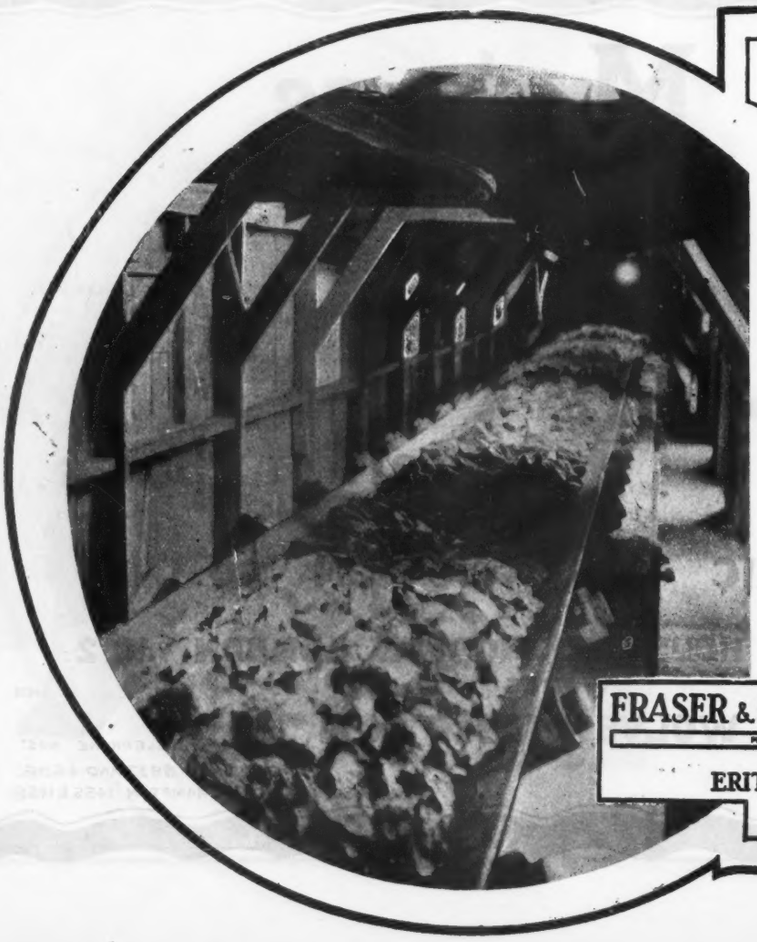

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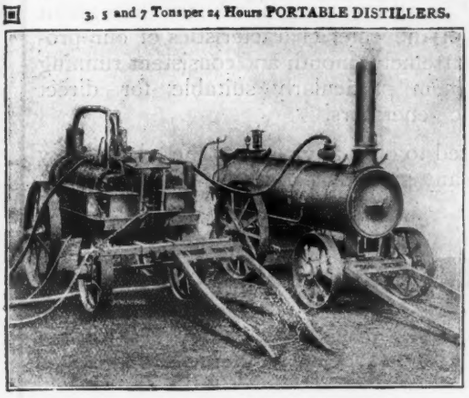

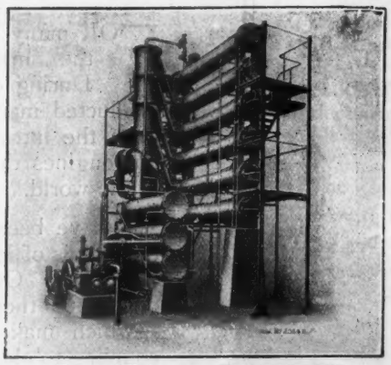

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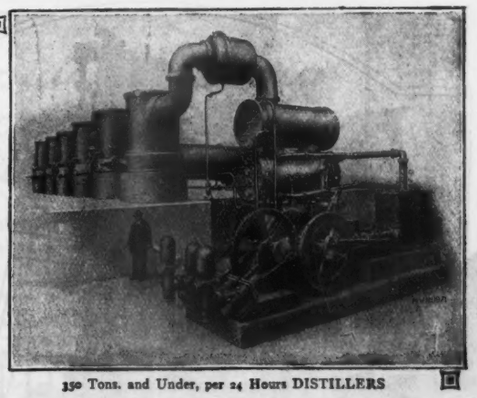

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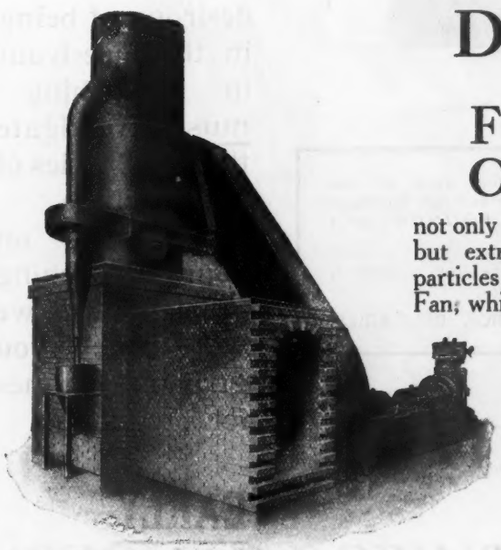

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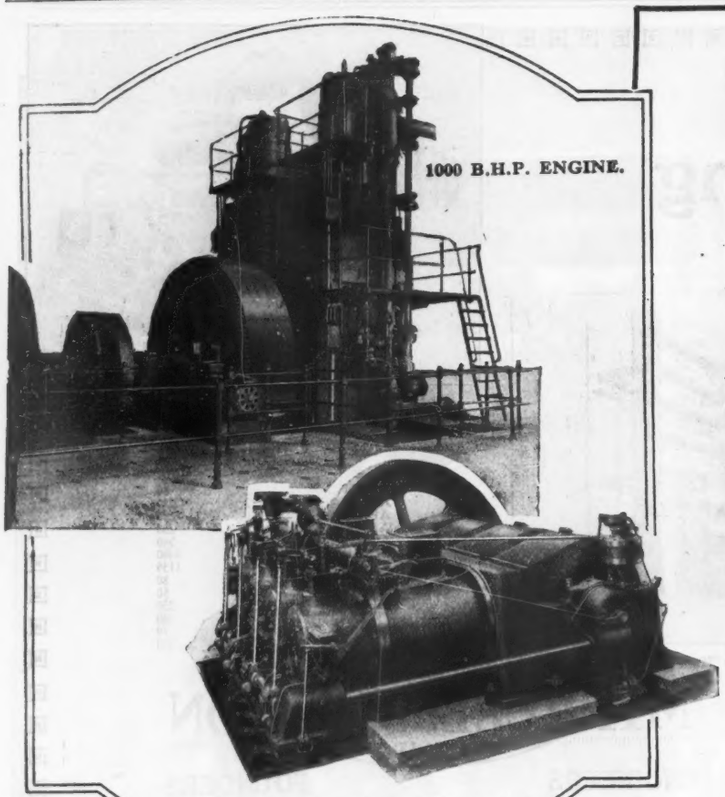

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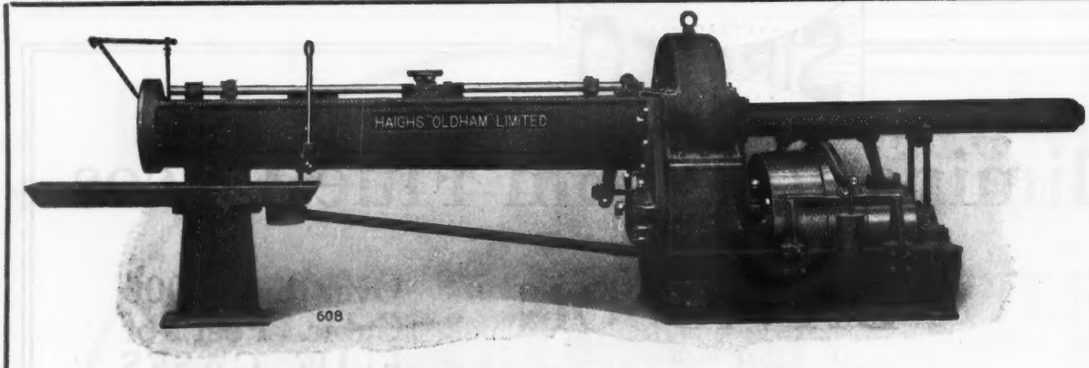

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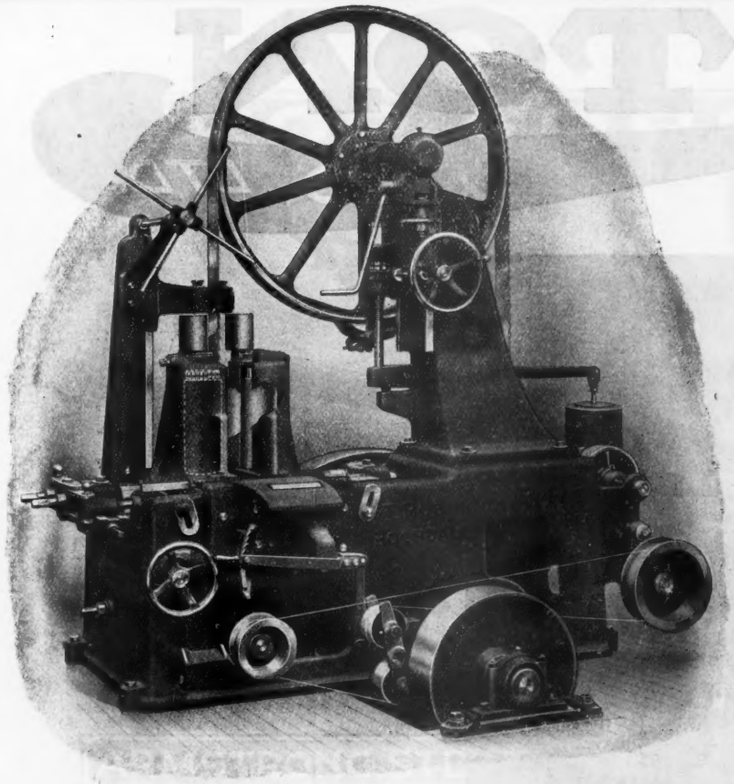

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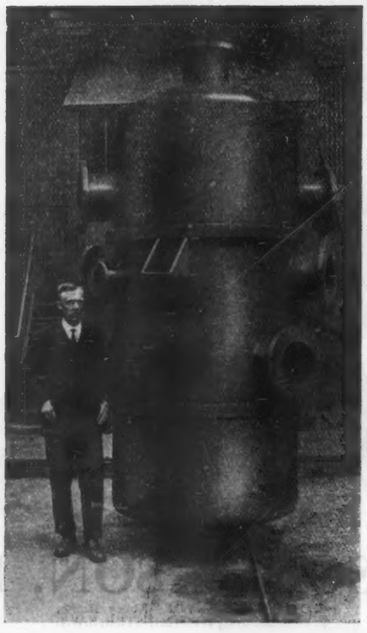

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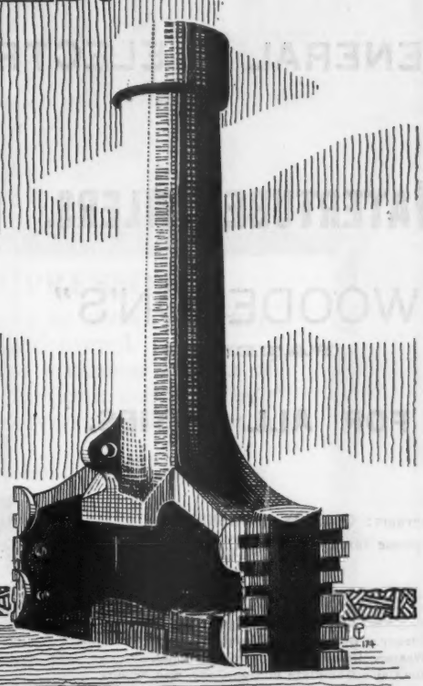

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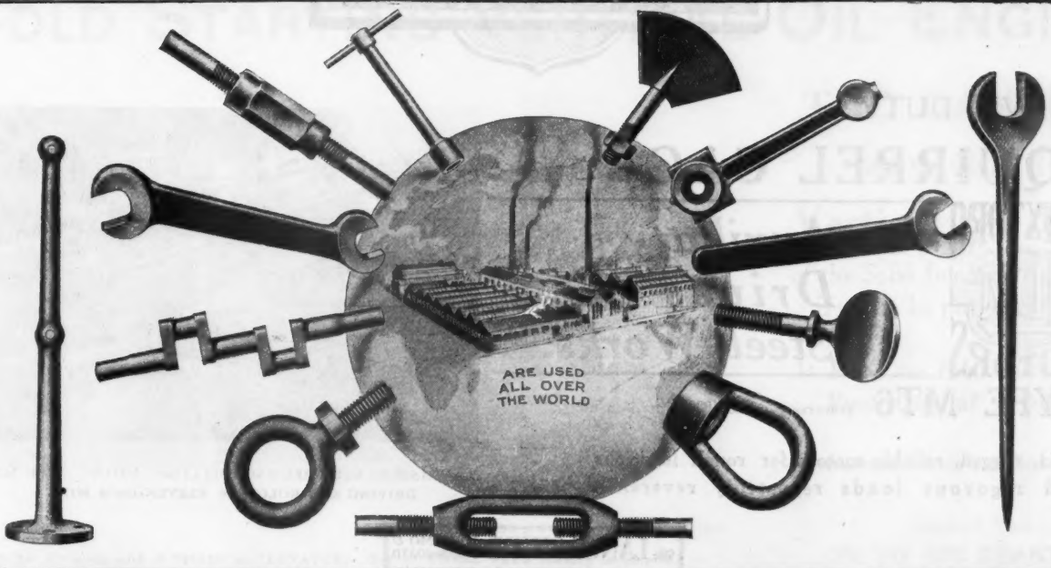

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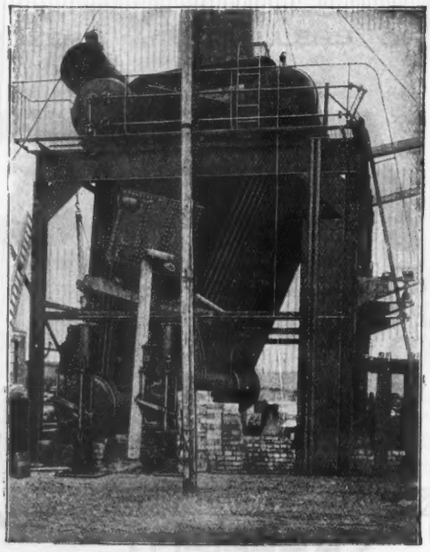

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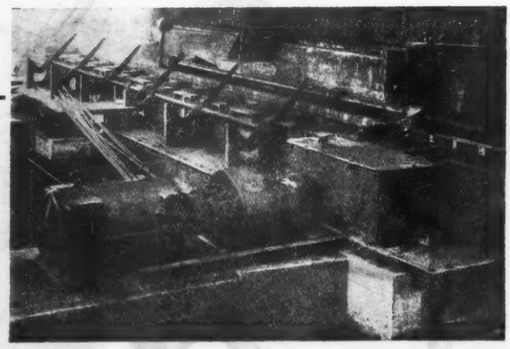

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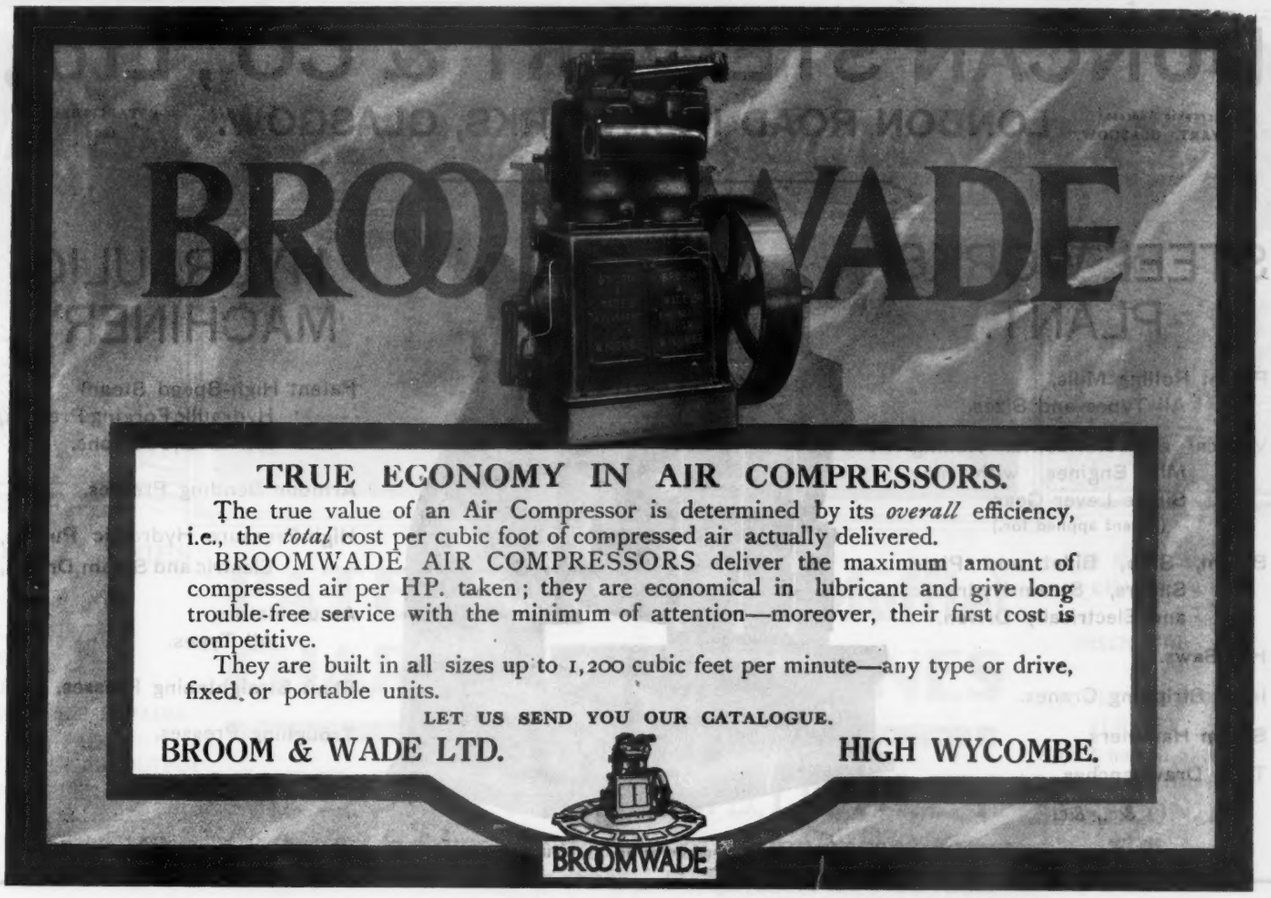

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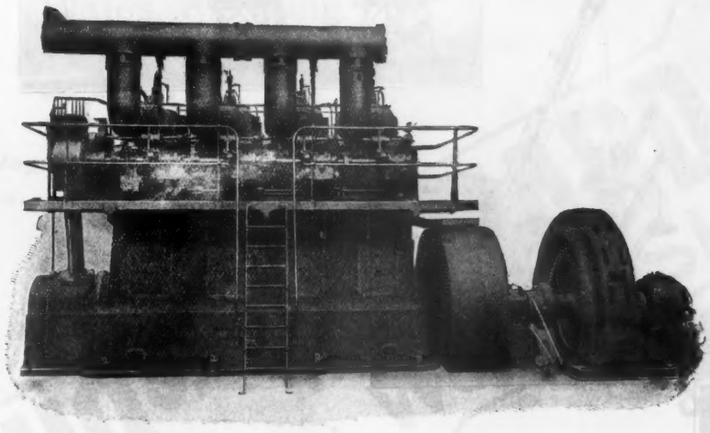

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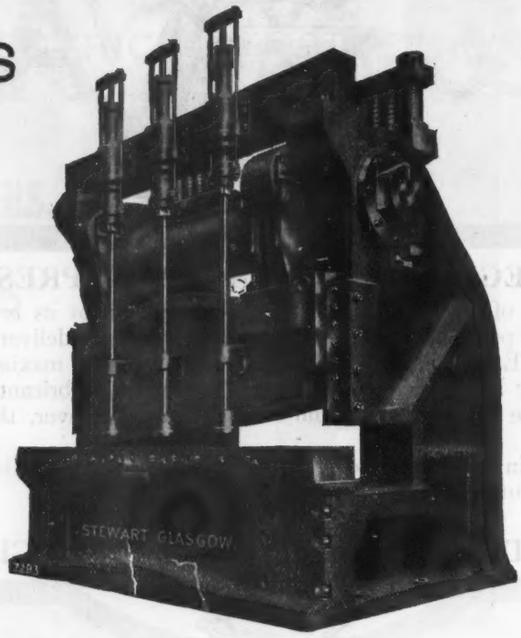

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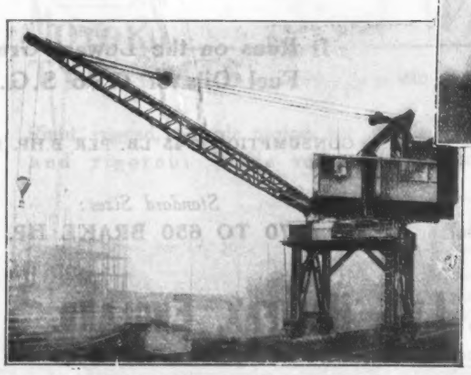

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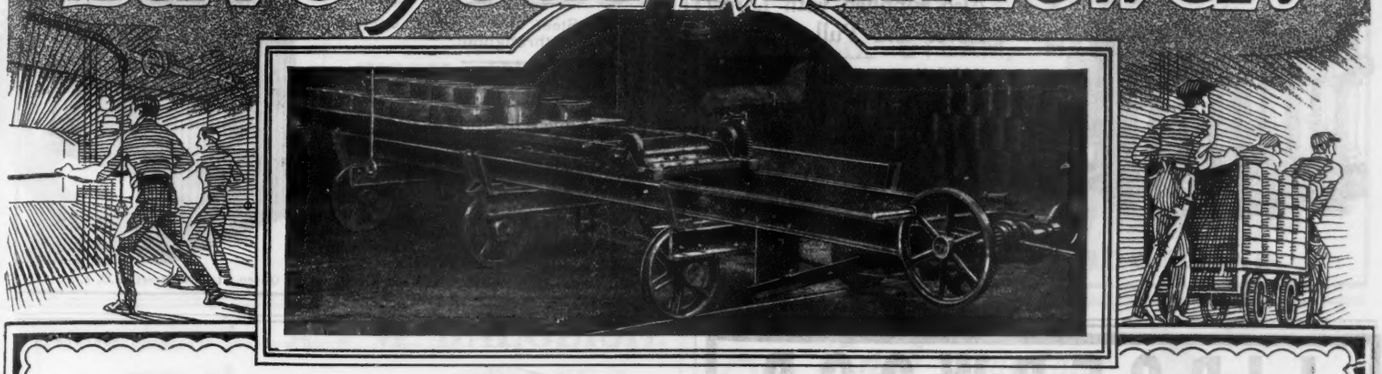

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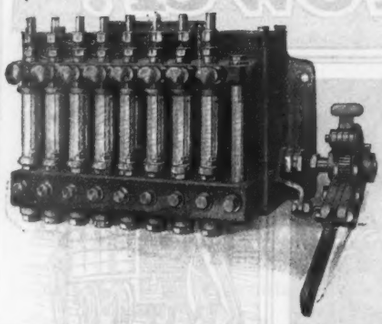

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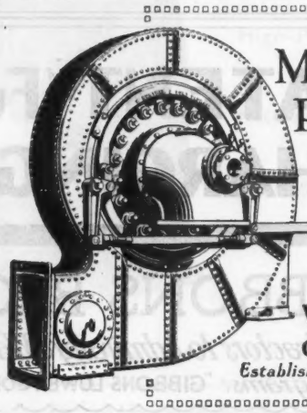

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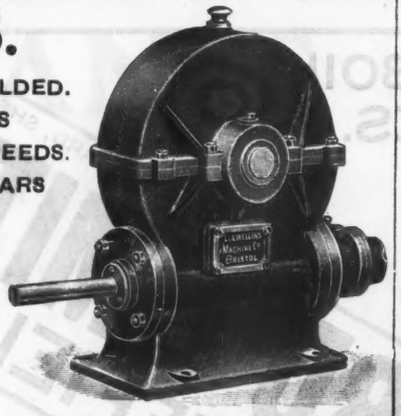

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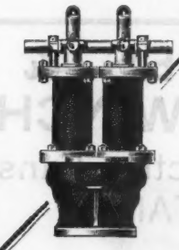

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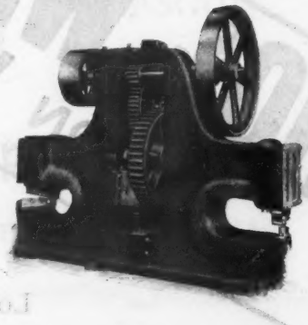

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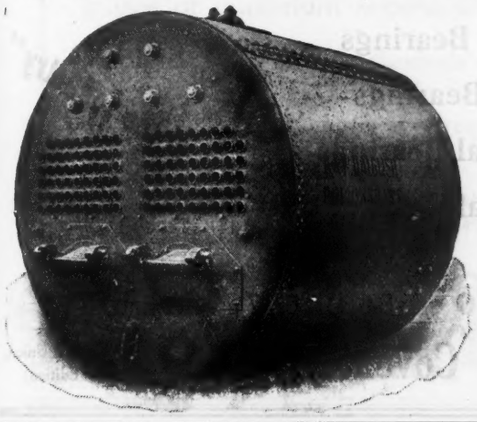

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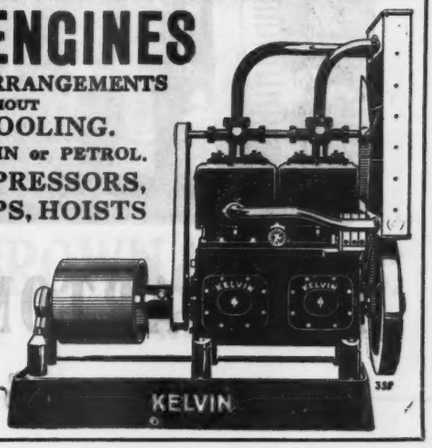

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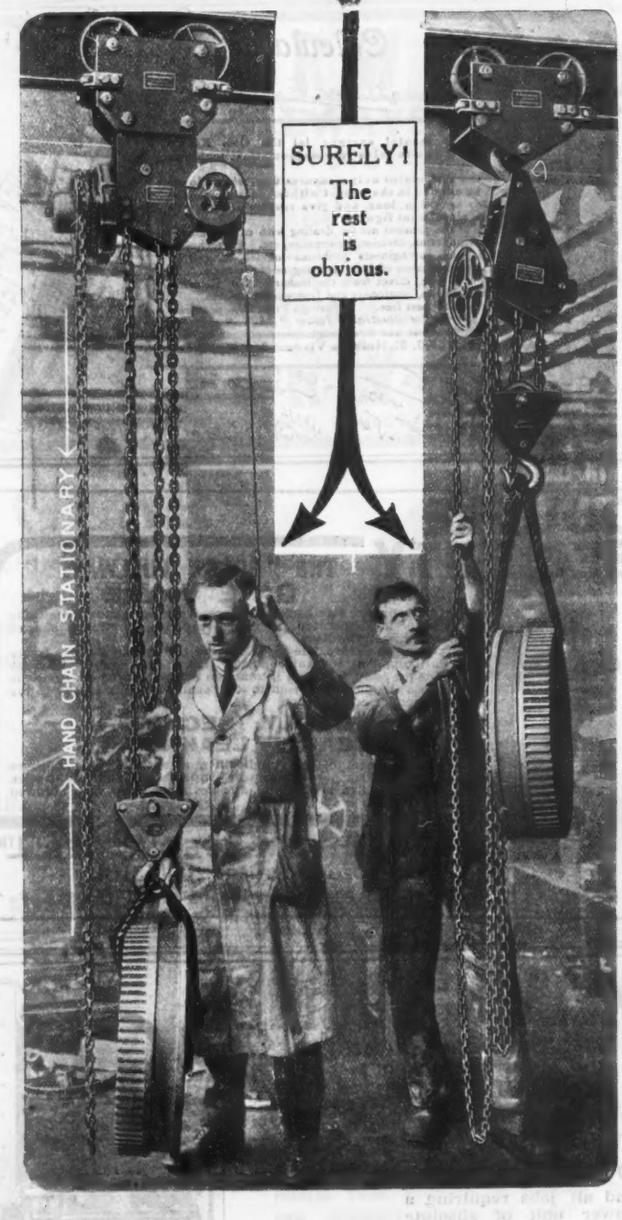

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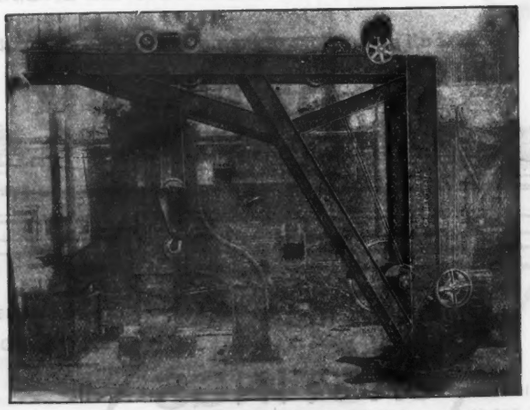

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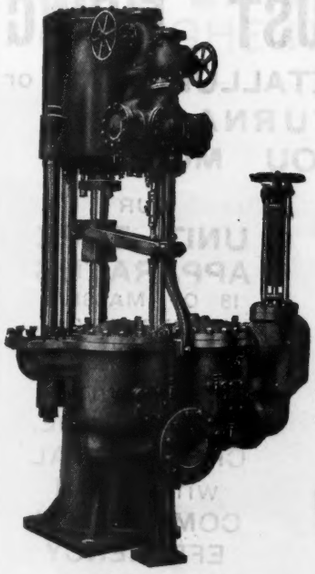

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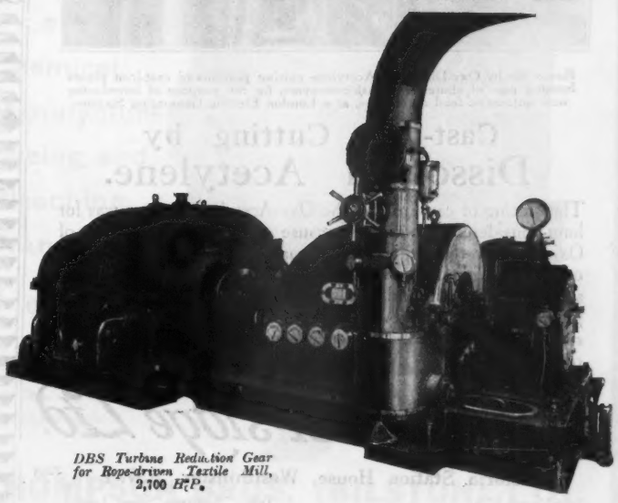

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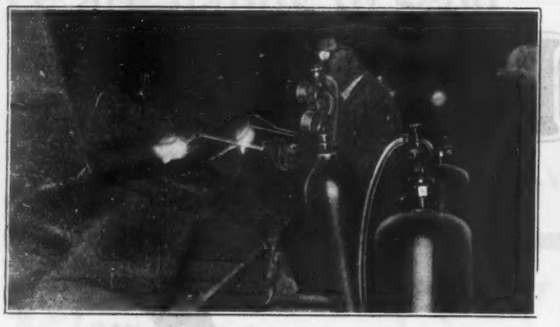

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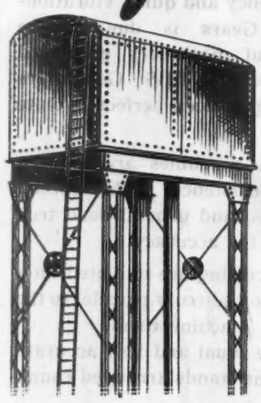

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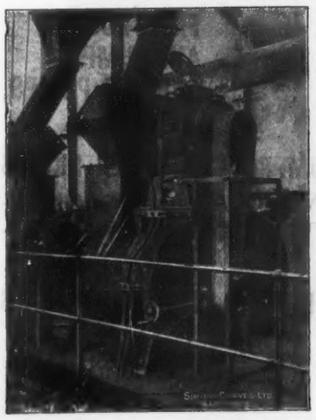

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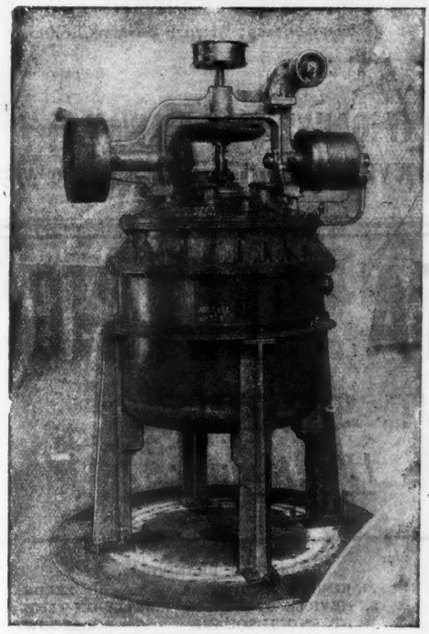

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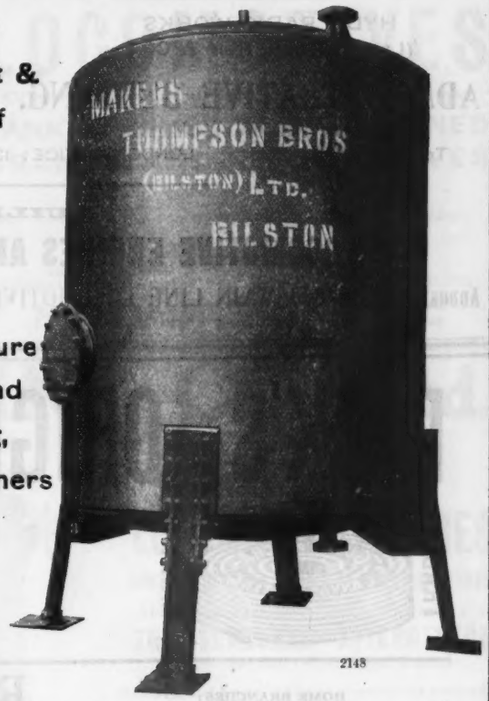

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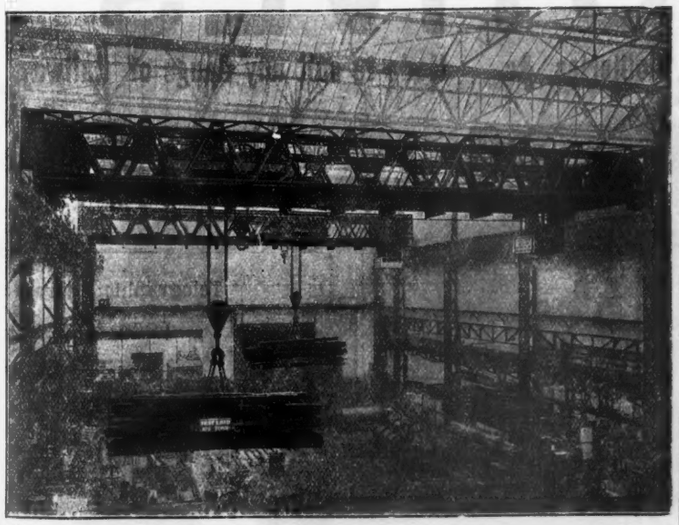

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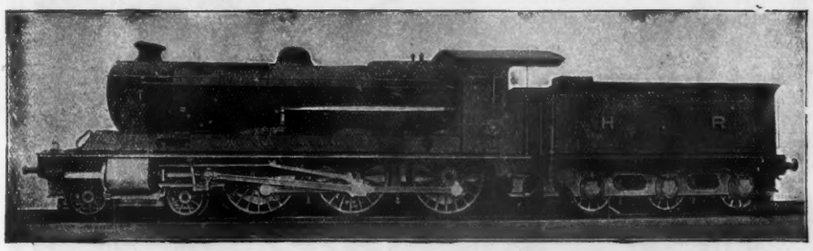

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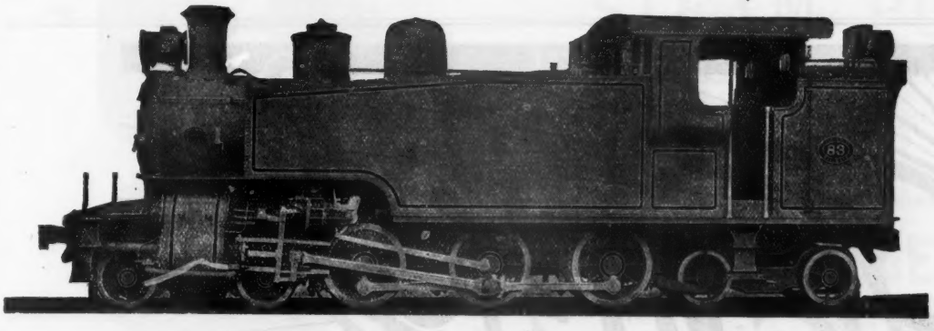

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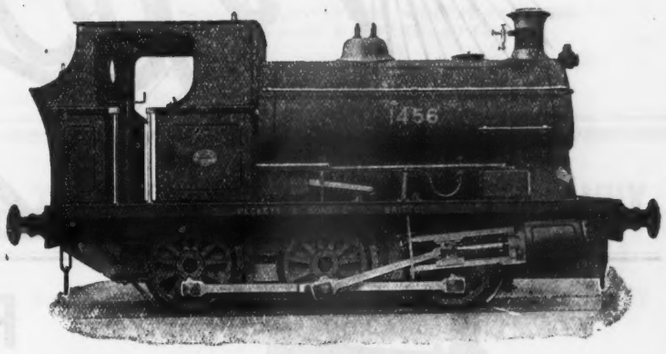

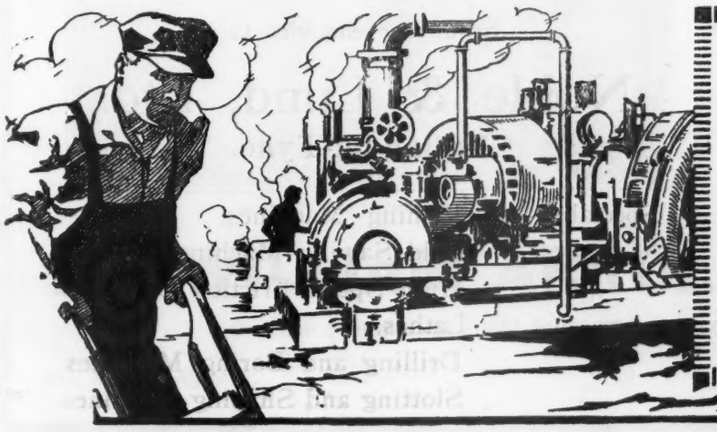

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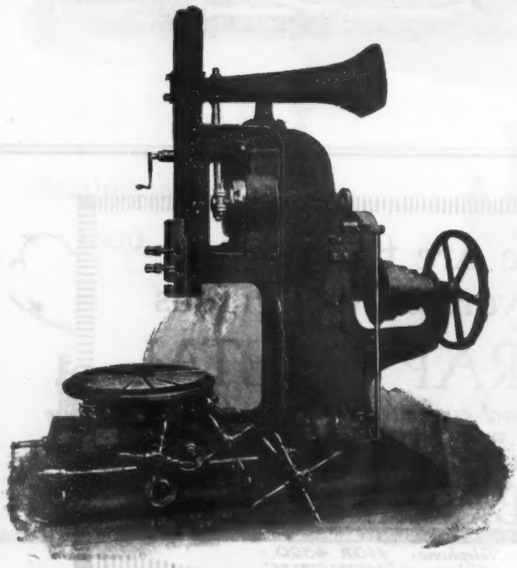

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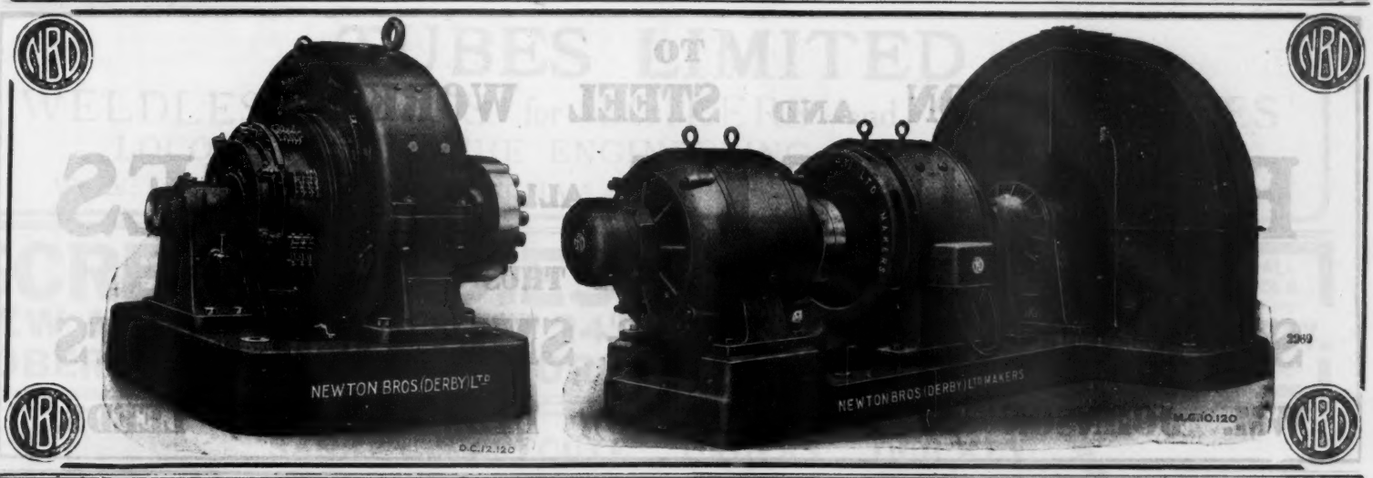

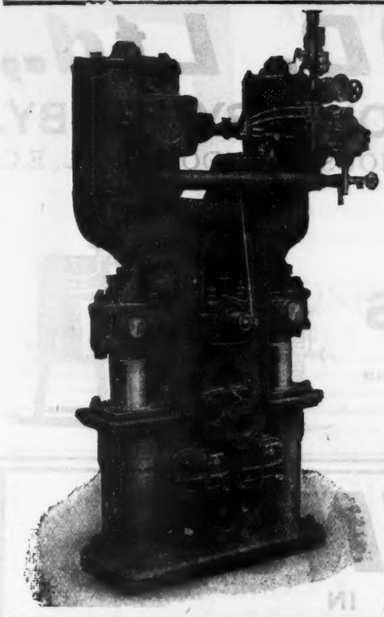

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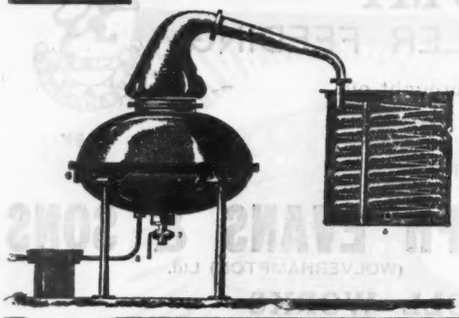

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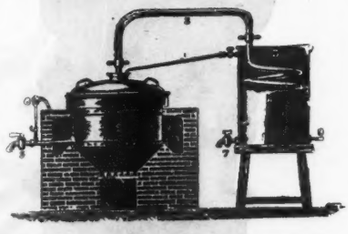

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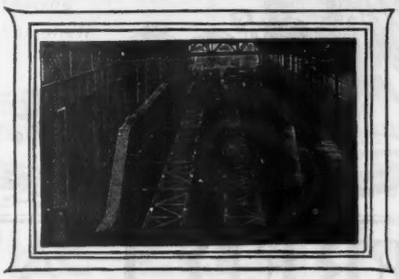

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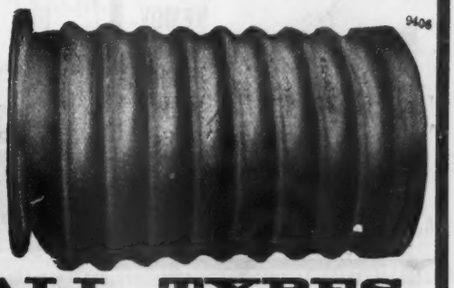

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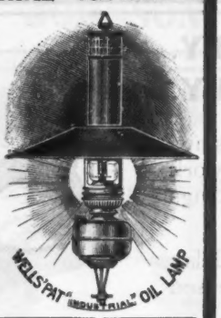

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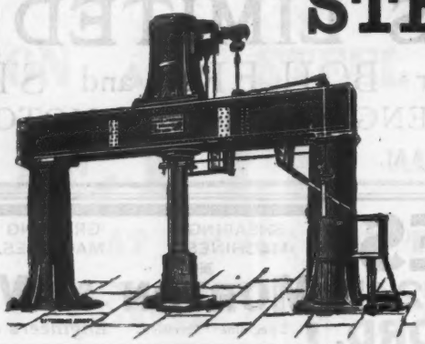

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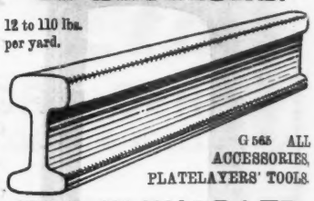

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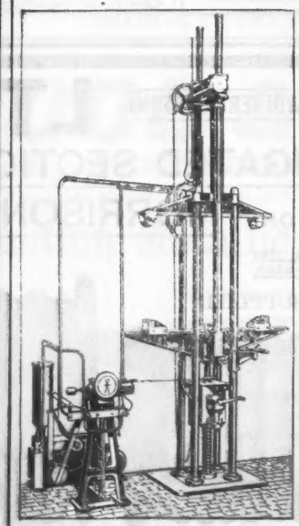

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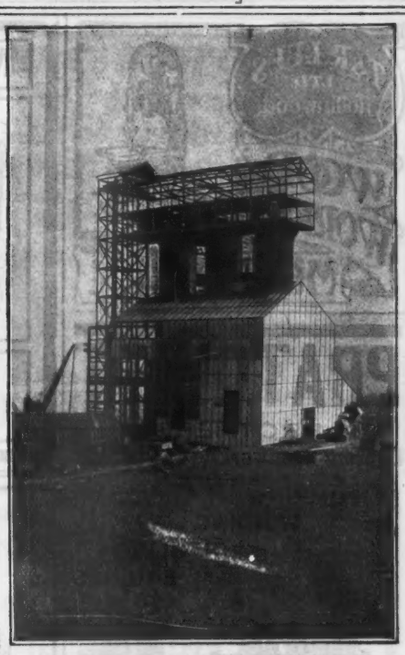

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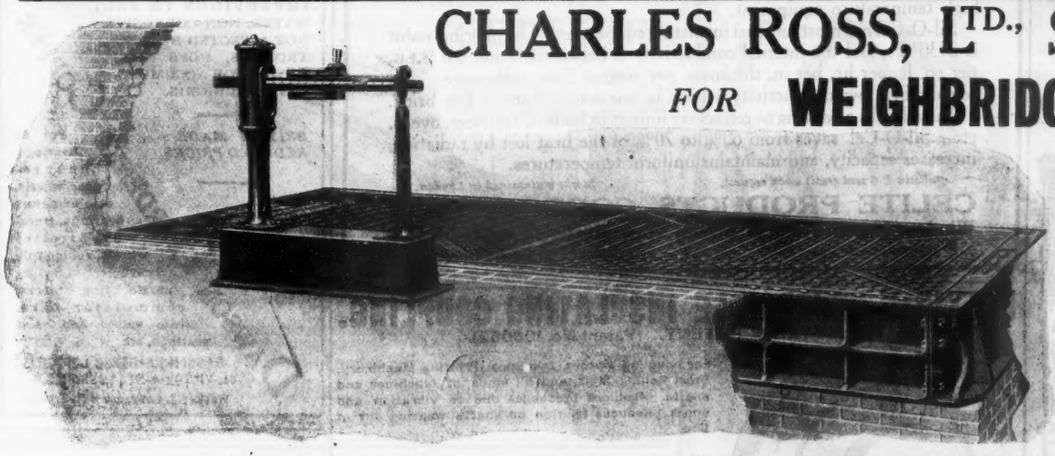

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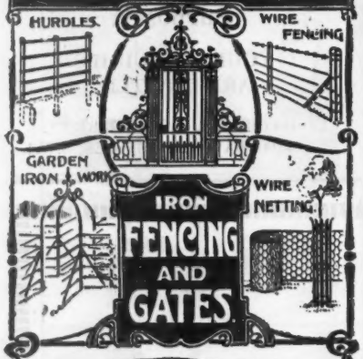

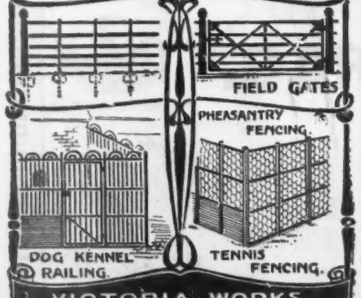

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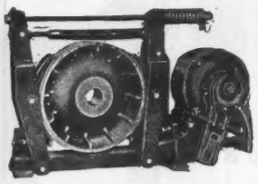

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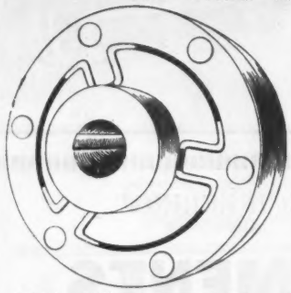

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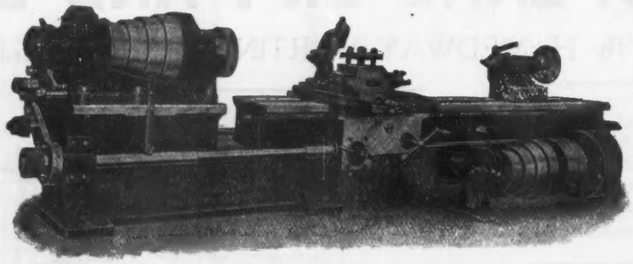

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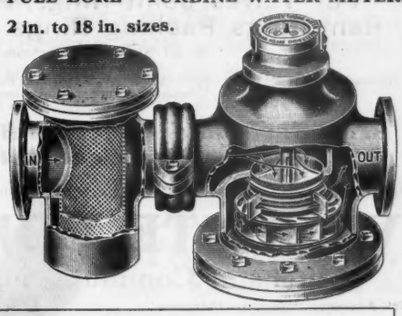

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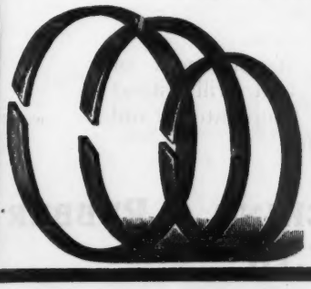

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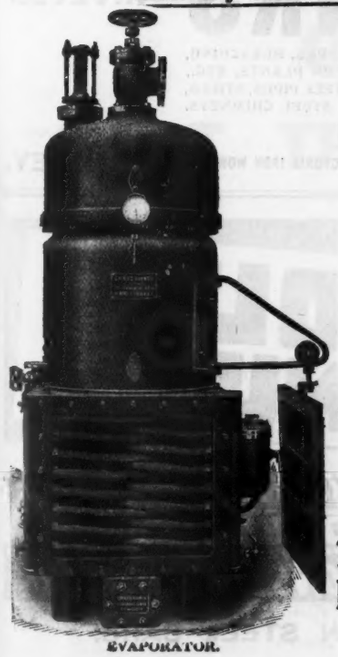

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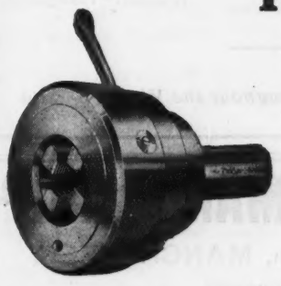

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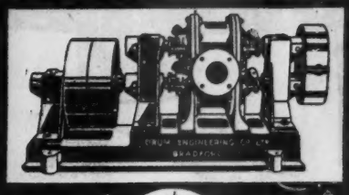

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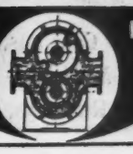

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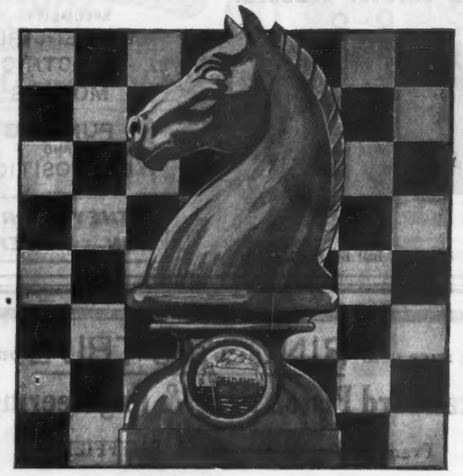

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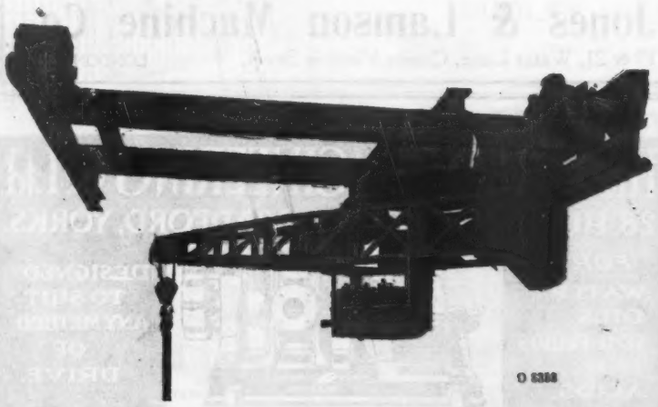

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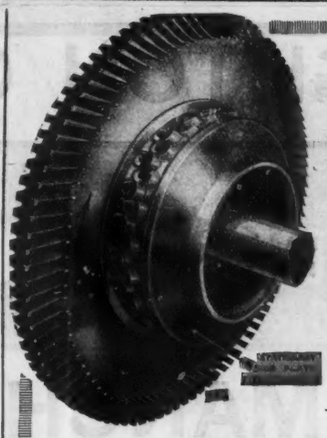

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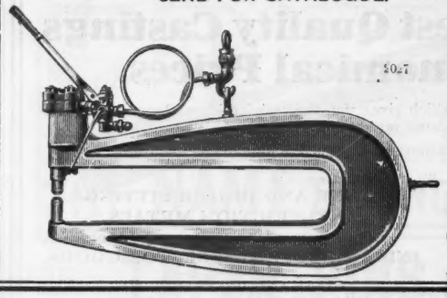

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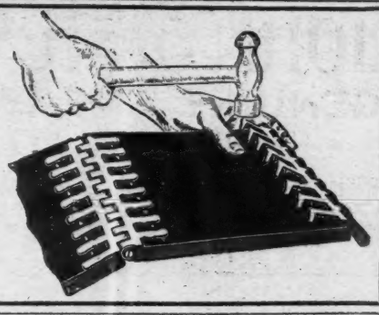

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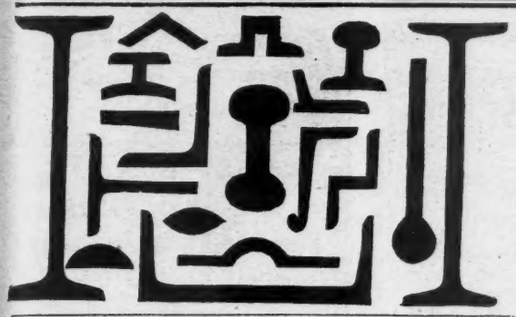

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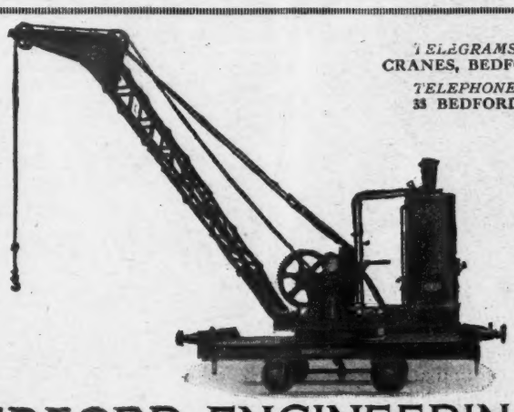

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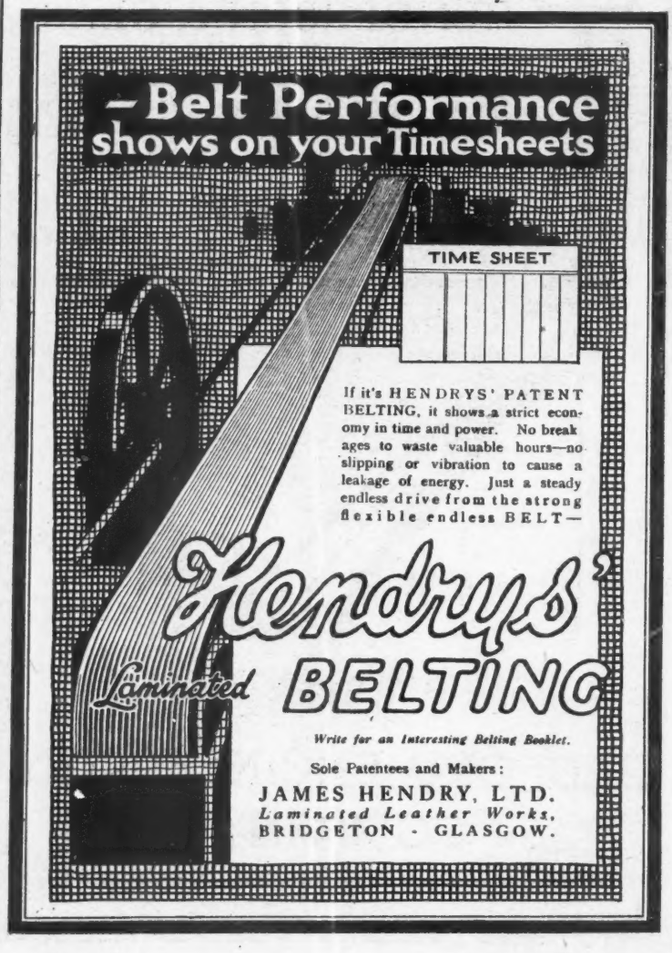
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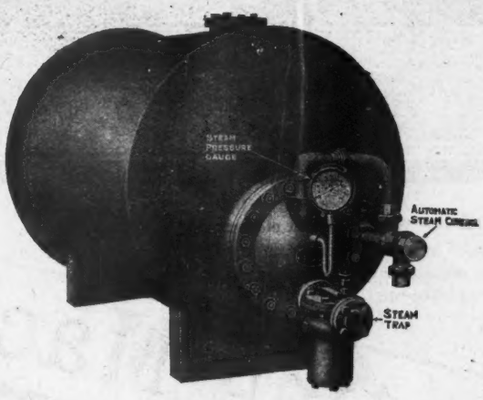

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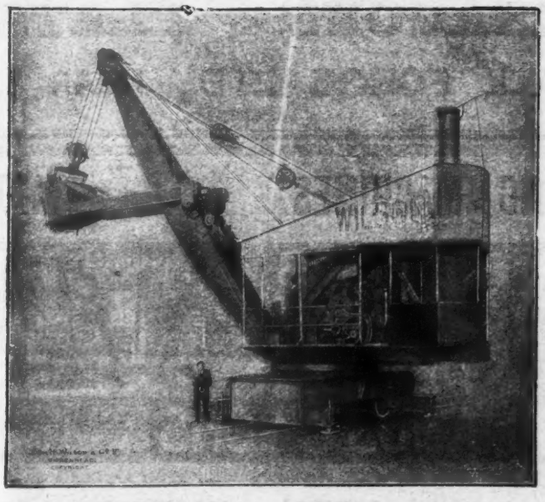
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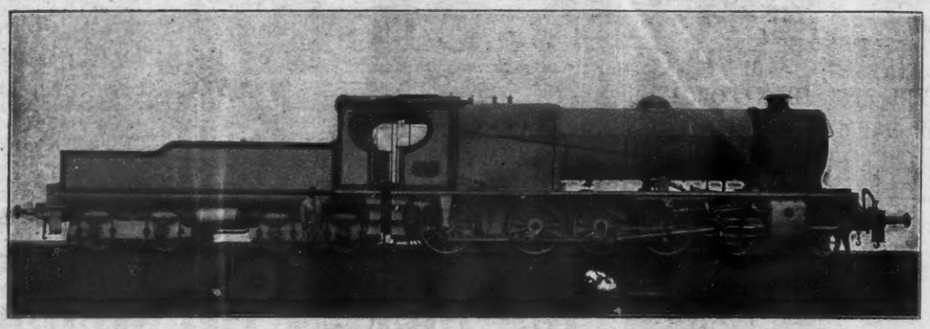

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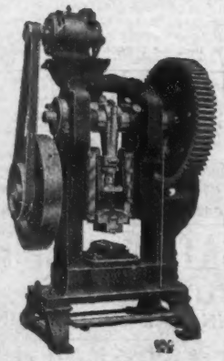

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